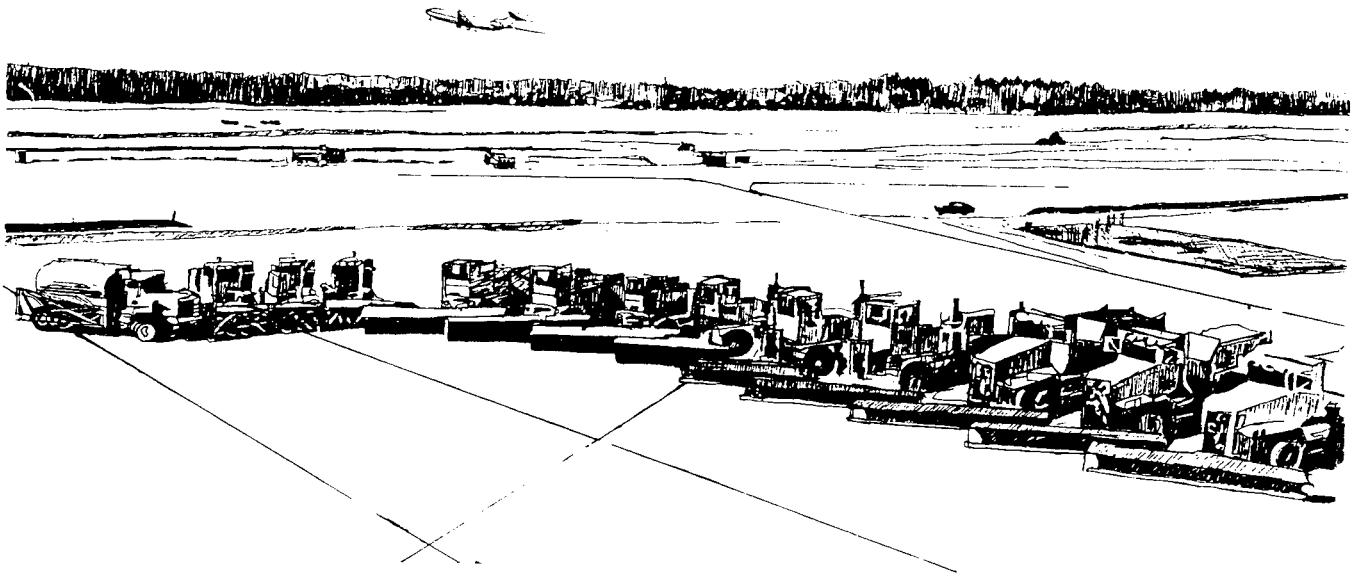
U.S. Department
of Transportation
**Federal Aviation
Administration**

Airport Snow and Ice Control Equipment

AC: 150/5220–20
DATE: 6/30/92



Initiated by: AAS–100

U.S. Department
of Transportation

Federal Aviation Administration

Advisory Circular

Subject: AIRPORT SNOW AND ICE CONTROL EQUIPMENT

Date: 6/30/92
Initiated by: AAS-120

AC No: 150/5220-20
Change:

1. **PURPOSE.** This advisory circular (AC) provides guidance to assist airport operators in the procurement of snow and ice control equipment for airport use.

2. **CANCELLATION.** This advisory circular cancels AC 150/5220-11, Airport Snowblower Specification Guide dated 4/10/78.

3. **VEHICLE MOVEMENT COORDINATION.** Vehicle movements on airport operational areas shall be conducted in accordance with FAR Part 139.329 and appropriate provisions of AC 150/5200-30A, Airport Winter Safety and Operations.

4. **APPLICATION.** The Federal Aviation Administration (FAA) recommends the use of the guidance contained in this publication for procurement of snow and ice control equipment at civil airports. For airport projects receiving Federal grant-in-aid assistance, the use of these standards is mandatory and equipment procurement must be made through the competitive bidding process.

Raymond T. Uhl

for LEONARD E. MUDD
Director, Office of Airport Safety and Standards

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Appendix 3 Rotary Plow Specifications....(3 pages)
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CHAPTER 1. OVERVIEW

1. **BACKGROUND.** Runways and taxiways should be maintained, if possible, to a "no worse than wet" condition during inclement weather. To meet this challenge, the purchase of snow and ice control equipment will not only require significant financial commitments, but also careful planning. Selection of equipment is based to a large extent on manufacturer's specifications. This Advisory Circular (AC) is designed to facilitate the purchase of equipment that is acceptable to the Federal Aviation Administration (FAA) for use on airports.

2. **CLASSIFICATION.** Snow and ice control equipment is generally classified by category based on the specific task that the equipment was designed to perform. This AC discusses several of these categories, e.g. rotary and displacement plows, material spreaders, and carrier vehicles.

3. **CONTENT.** Chapters 1-7 describe this equipment and present methods of selecting and testing that will meet sponsor needs and ensure compliance with manufacturer's claims. The remaining portion of the AC deals with equipment specifications. For example, appendix 1 contains specifications for a generic carrier vehicle while appendix 2 lists equipment options available for carrier vehicles, rotary plows, displacement plows, and material spreaders. Appendices 3, 4, and 5 cover specifications for rotary plows, displacement plows, and dry and liquid spreaders.

4. **FRICTION TESTING EQUIPMENT.**
Specifications for friction testing equipment used to conduct runway friction surveys during winter operations are found in AC 150/5200-30A, Airport Winter Safety and Operations and AC 150/5320-12B, Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces.

5. **USE OF SPECIFICATIONS.** These specifications can be used individually or in combination with one another. For example, an airport operator desires to acquire a new self-propelled rotary plow. This unit consists of a carrier vehicle and a rotary plow head assembly. The operator would combine information in Appendix 1 with Appendix 3 and, if necessary, appropriate parts of Appendix 2 for the required specification. On the other hand, if only a rotary plow head assembly were required, Appendix 3 is all that is needed.

6. **VARIABLE USE OF EQUIPMENT.** Depending upon conditions, a displacement plow supported by a sweeper may be all that is required to keep an airport open to traffic. At other airports, more diverse equipment may be needed. In assessing airport needs, the airport operator must compare the cost/benefit relationship of acquiring a multifunctional piece of equipment offering a number of attachments versus the acquisition of a single unit designed primarily to accomplish one task.

7. **CERTIFICATION.** Purchasers of equipment described in this AC should obtain a certification in writing from the vendor that the components constituting the whole of the equipment being supplied comply with the applicable performance, design or construction requirements of this specification. This certification is required if the equipment is purchased with Federal funds. In this event, a signed copy of the certification shall be made part of the equipment documentation.

8. **METRIC UNITS.** In order to promote an orderly transition to metric (SI) units, this AC contains both English and metric dimensions. The metric conversions may not be exact and pending an official changeover to this system, the English system governs.

9. **RESERVED**

CHAPTER 2. ROTARY PLOWS

10. **DESCRIPTION.** Rotary plows, also called "rotaries" or "snowblowers," are primarily used to cast heavy concentrations of snow away from airport operational areas such as runways and taxiways. The equipment, which may be self-propelled or attached to a carrier vehicle, uses either one or more rotating elements (single or two-stage units) to disaggregate a snowpack. The disaggregated snow is then broken into particles small enough to pass through a casting mechanism and directional chute. Because of their large capacity, self-propelled rotary plows are frequently required at medium to large airports while rotary plows attached to a carrier vehicle may be more appropriate at smaller facilities or facilities where the climate is less severe.

a. **Single-Stage Rotary Plows.** Single-stage rotary plows use one rotating device to accomplish both the disaggregating and the casting functions. Single-stage rotaries may be of any suitable design with either single or dual turbine fans and with or without moveable or fixed side extension wings. Two common designs are the scoop wheel type (figure 2-1), which may have a propeller-like precutter bar to break up hard snow, and the drum with turbine impeller type (figure 2-3g).

b. **Two-Stage Rotary Plows.** Two-stage rotary plows separate the snow gathering or disaggregating function from the casting function (figures 2-2 and 2-3). Disaggregators can be of any suitable design, such as a solid auger (single or dual) or ribbon reel (helical). Impellers, which cast the snow, can be of web or disk design.

c. **Options.** In selecting a rotary plow design (single or two stage) to meet the demands of local conditions, an airport operator should consider the various equipment options available to ensure that only the most effective unit is acquired.

11. **SNOW REMOVAL REQUIREMENT.** Snow removal requirements are based on the annual operations at an airport and the amount of surface area to be cleared. These variables are described in AC 150/5200-30A, Airport Winter Safety and Operations, and must be determined as the first step in rotary plow selection. In areas of heavy snow concentration, the rotary plow is selected first because it dictates the selection of support equipment. Figures 2-4 and 2-5 reflect an acceptable method of rotary plow selection.

12. **ROTARY PLOW CAPACITIES.** Capacities for various rotary plow classes are shown in Table 2-1 and may be acquired in either single or two-stage design. Their capacities are in tons/hour and the casting distance shall be measured from the longitudinal centerline of the snow removal unit to the center of mass within the perimeter of the cast pattern. The test shall be conducted when there is no wind.

13. **ROTARY PLOW SELECTION.** Guidance on the selection of rotary plows may be found in Chapter 6.

14. **SUPPORTING CARRIER VEHICLE.** Carrier vehicles on which rotary plows are mounted should conform to the specifications in appendix 1 and to the plow manufacturer's recommendations for axle loading, operator visibility, and power train. For vehicle controllability and safety, all-wheel drive shall be standard. Figure 2-6, GVW and Horsepower rating for Rotary Plows, shows the weight/horsepower (H.P.)/ snow capacity relationship between rotary plow classes.

Table 2-1. ROTARY PLOW CAPACITIES

Plow Size	Class	Casting Distance (1) Feet	Meters	Minimum Capacity Tons/h (2)
Small	I	50	15.2	Up to 600
Medium	II	75	22.9	1500
Intermediate	III	100	30.5	2500
Large	IV	100	30.5	3000
Very Large	V	100	30.5	4000
		150	45.8	3000
Extra Large	VI	100	22.9	5000 and >

(1) As measured in paragraph 12. **Rotary Plow Capacities.**
(2) As measured in paragraph 47. **Rotary Plow Test.**

15-16. **RESERVED.**

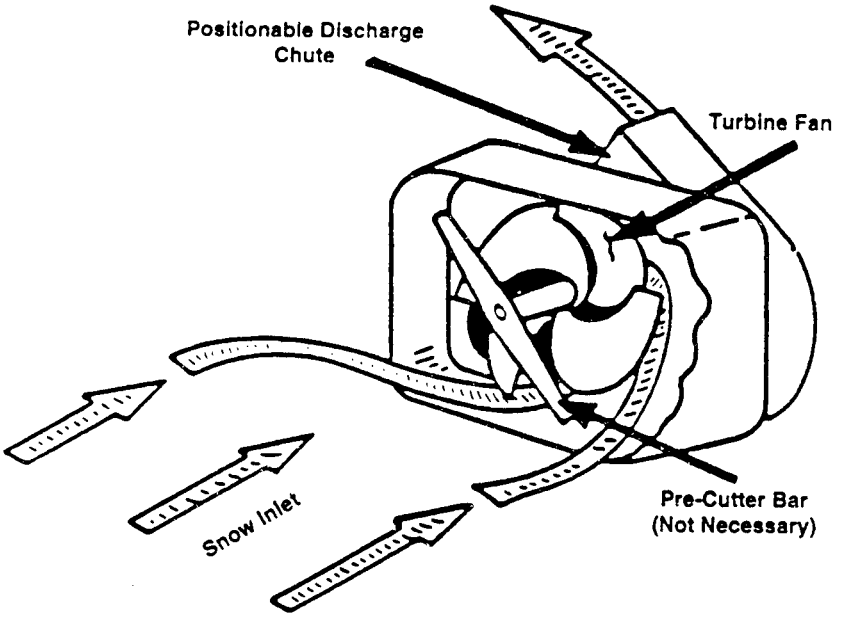


Figure 2-1. Single-stage Rotary Plow

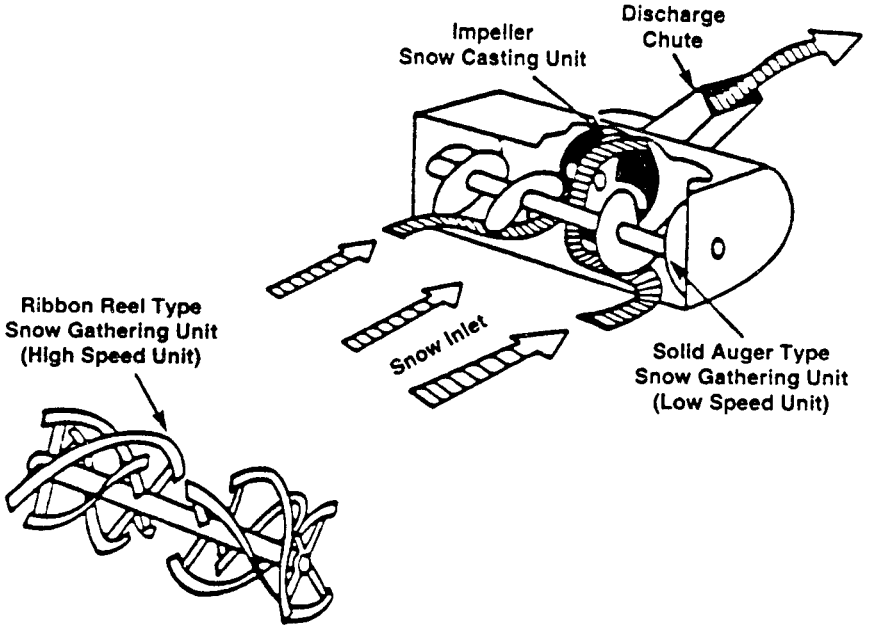
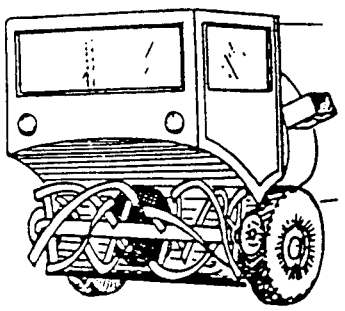
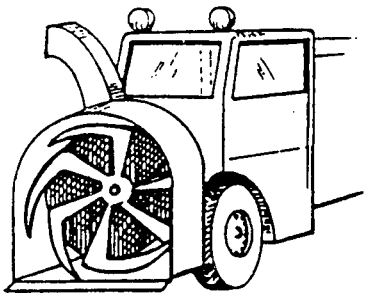


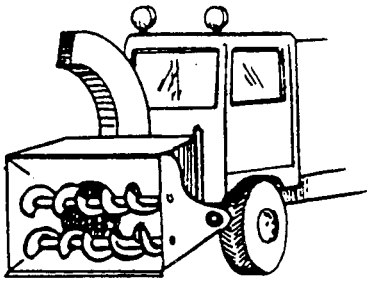
Figure 2-2. Two-stage Rotary Plow



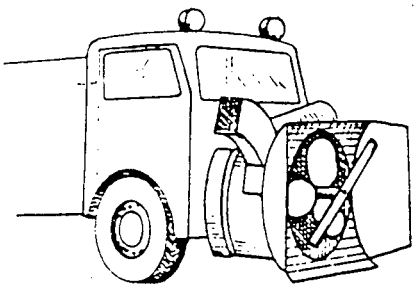
Two stage single auger
helical ribbon type
A



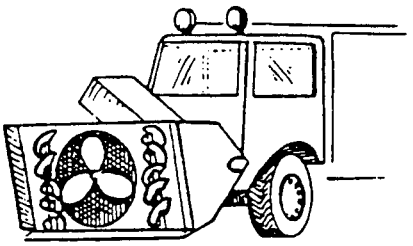
Single stage
rotary type
B



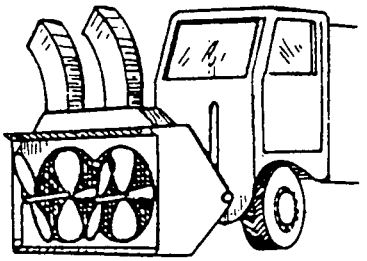
Two stage dual auger
solid auger type
C



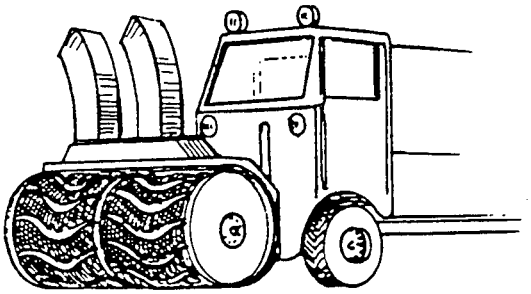
Single stage
single fan with cutter bar
D



Two stage with
vertical side augers
E



Single stage
dual fan with cutter bars
F



Single stage
dual cutter drums with
turbine impeller
G

Figure 2-3. Typical Rotary Plow Types

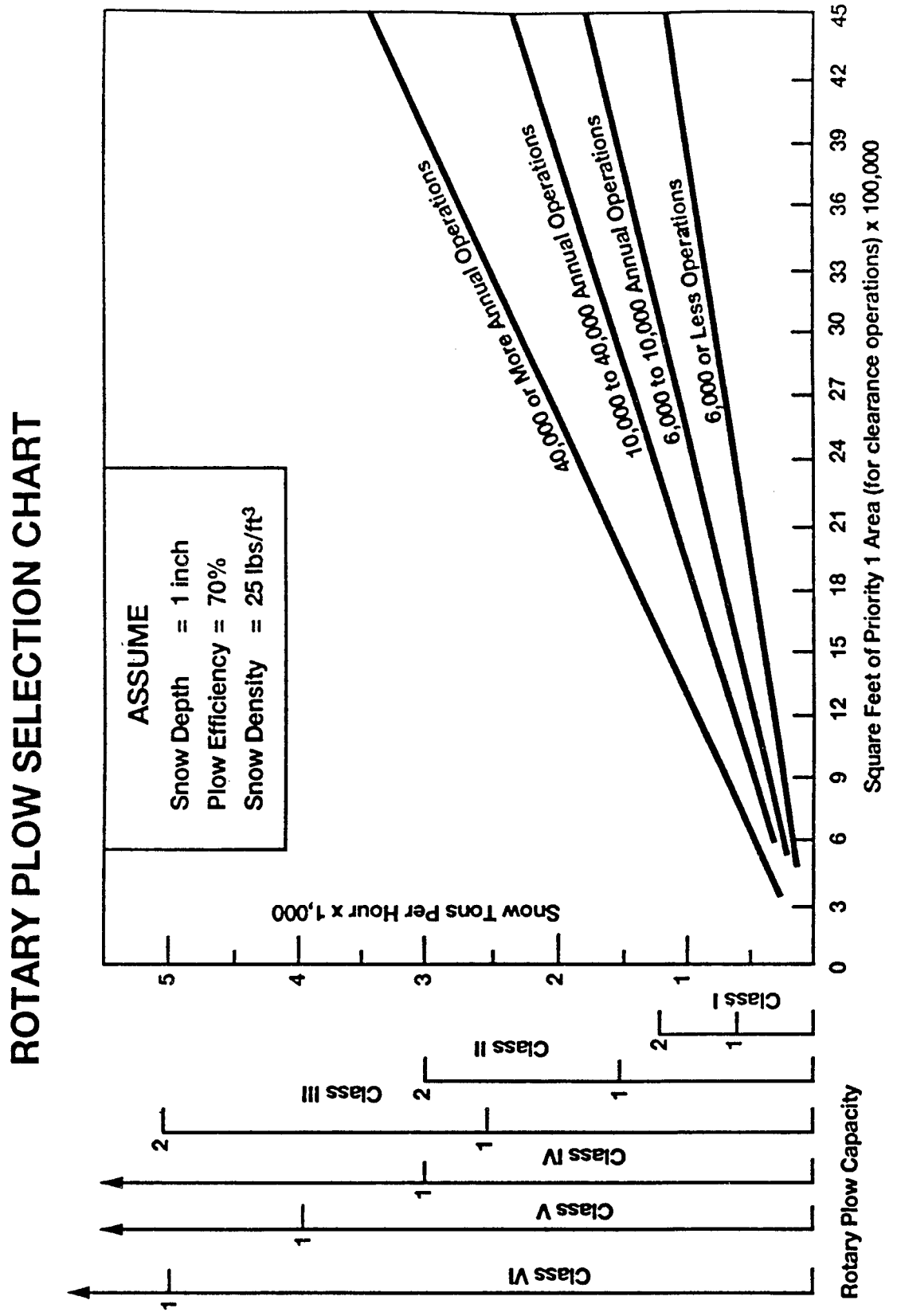


Figure 2-4. Rotary Plow Calculations for Airports Without Commercial Service

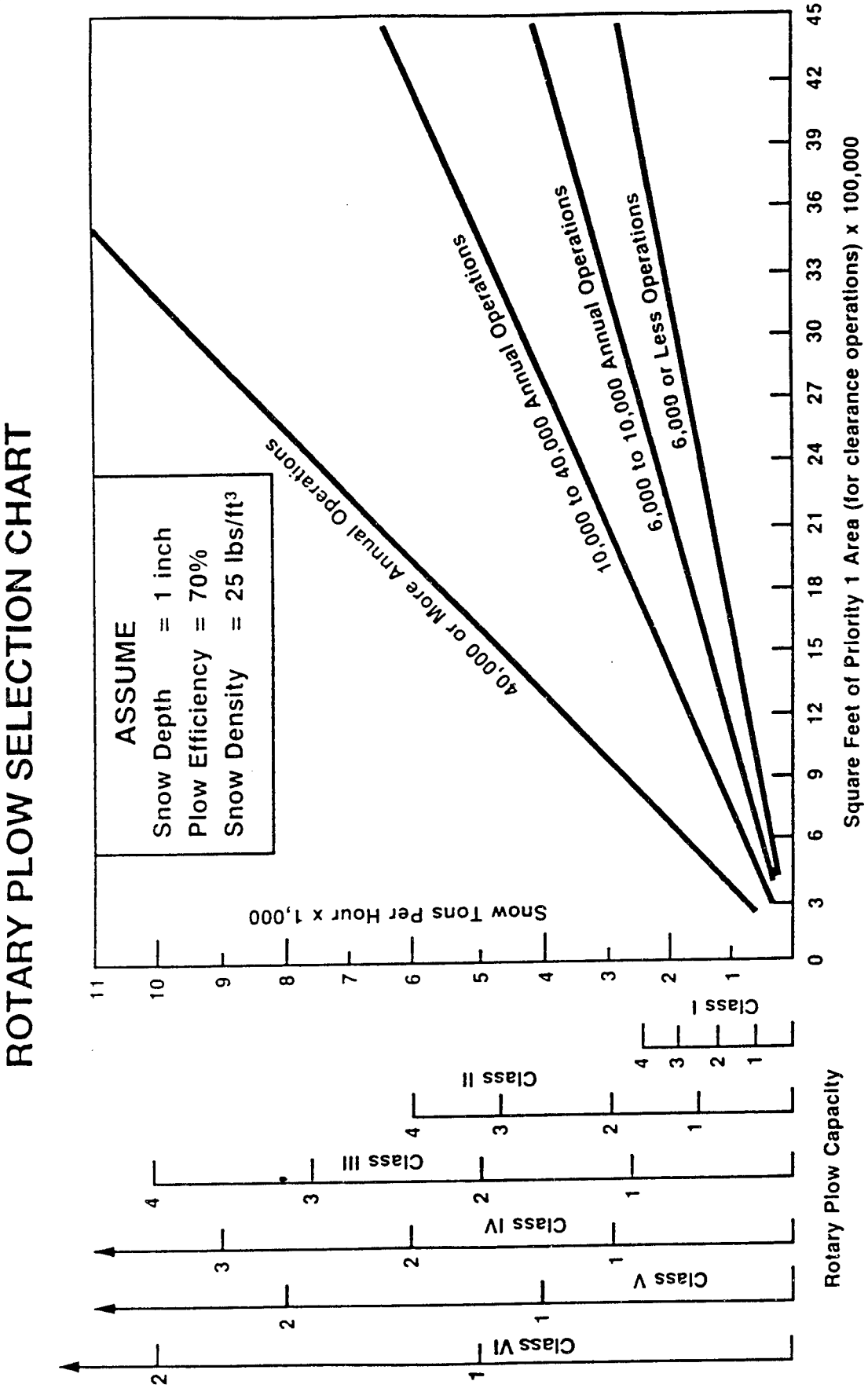


Figure 2-5. Rotary Plow Calculations for Airports With Commercial Service

Gross Vehicle Weight. The gross vehicle weight (GVW), including weight of the complete chassis and cab with rotary plow, all attachments, accessories, and equipment required by this specification; full complement of fuel, lubricants, coolant, and operating personnel is shown for each class of vehicle. The gross vehicle weight rating shall not exceed the sum of the axle manufacturer's certified load ratings for axles used. The horsepower ratings should be used as general guidelines only, some machines are inherently more efficient than others. Capacity and casting distance shall be the primary vehicle selection criteria.

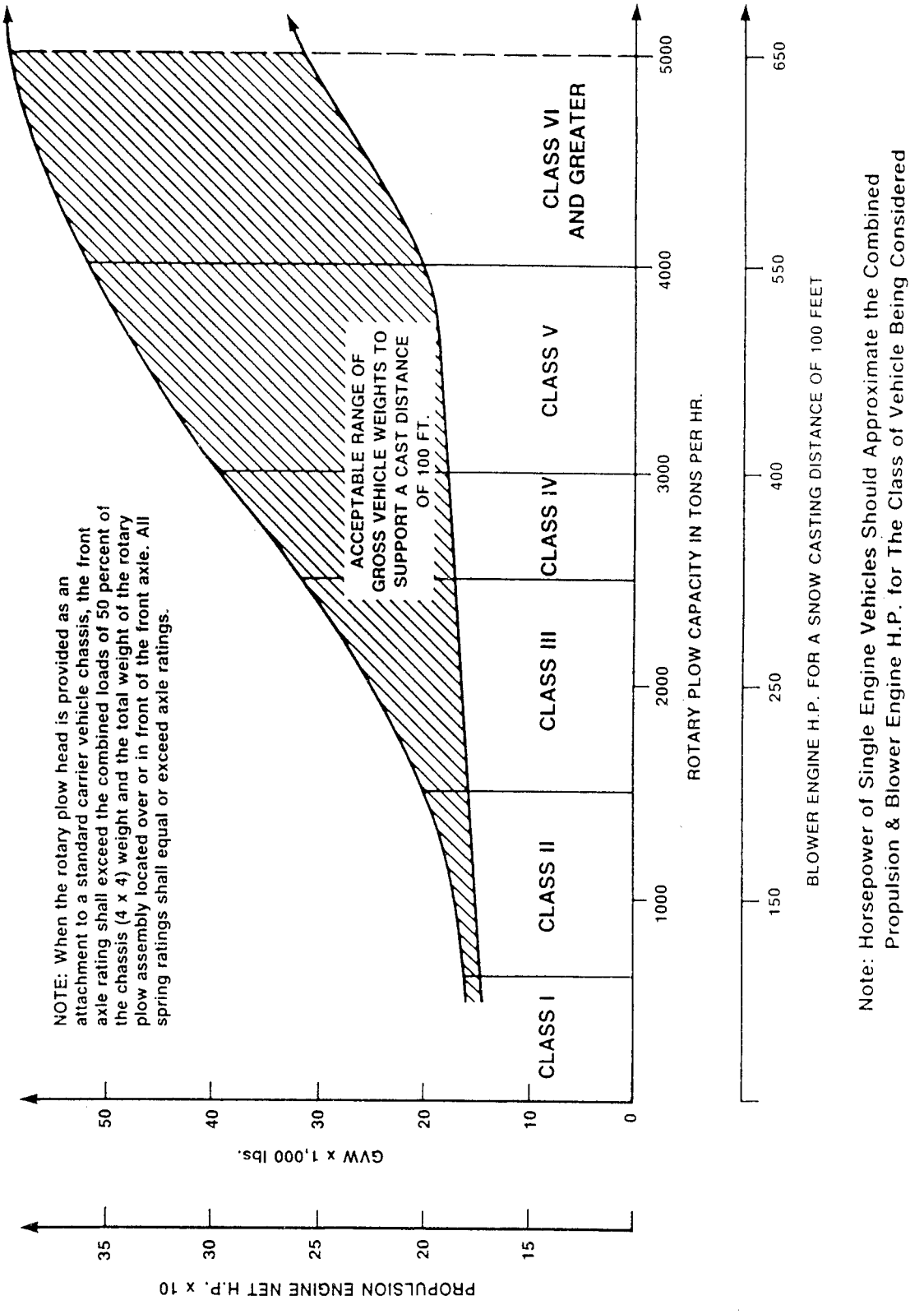


Figure 2-6. GVW and Horsepower Rating for Rotary Plows

CHAPTER 3. DISPLACEMENT PLOWS

17. **DESCRIPTION.** Displacement plows consist of a cutting edge to shear snow from the pavement and a moldboard to lift and cast the dislodged snow to the side of the cleared path. The cutting edge may ride in contact with the pavement or be held a small distance above it by means of shoes or caster wheels. A complete displacement plow unit consists of a plow, carrier vehicle, and accessories (see figure 3-1). Plow sizes may be classified as follows:

a. **Small Plow.** This category includes plows with cutting edge lengths ranging from approximately 6 feet up to 10 feet (1.8 m up to 3.0 m). Included in this category are underbody-mounted truck scrapers with similar length cutting edges.

b. **Intermediate Plow.** This category includes plows with cutting edge lengths ranging from approximately 10 feet up to 15 feet (3.0 m - 4.6 m). Underbody-mounted truck scrapers with similar length cutting edges are also included in this category.

c. **Large Plow.** This category includes plows with cutting edge lengths ranging from approximately 15 feet up to 22 feet (4.6 m - 6.7 m). Ramp dozer plows and large special purpose plows are included in this category.

d. **Extra Large Plow.** This category includes plows with cutting edge lengths greater than 22 feet (6.7 m). This group also includes ramp dozer plows and extra large special purpose plows.

18. **PLOW USES.** Plows are most commonly mounted on the front of a carrier vehicle, but they may also be mounted on the side or underneath the vehicle.

a. **Front-Mounted Plows.**

1) **One-Way Fixed Angle Plow.** This unit is primarily used in large open area snowplowing operations that require a high-volume and high speed snow discharge at fixed left or right cutting angles.

2) **Power Reversible Plow.** This unit may be used for both large open area or confined area snowplowing operations. The design provides variable blade positions to either the right or left of the bulldozing position. This allows high volumes of snow to be displaced in a direction dictated by wind conditions or other constraints. The ability to reverse the plow angle improves operational efficiency and may reduce the number of plow units required.

3) **Rollover Power Reversible Plow.** The primary use of this unit is for large open area snowplowing operations. High-speed and high volume snow discharge to either a right or left cutting angle may be achieved by rotating the blade assembly through 180° degrees. This type of plow is not recommended for bulldozing. The rollover concept reduces snow spillage by confining and spreading it through a tapered moldboard design.

4) **Power Reversible Plow with Folding Wings.** The primary use of this unit is for wide and extra wide swath snowplowing operations at various rates of speed. Cutting an extra wide swath may require a special carrier vehicle having high horsepower (see figure 3-2). When not in use, the wings should be designed to fold snugly against the carrier vehicle chassis.

5) **Flexible Reversible Plow.** This unit is made of polymer construction and is capable of changing its crossectional shape. It is versatile and can be used as a one-way fixed angle plow or a power reversible plow with the added feature that it can be adjusted to fit a variety of weather and snow conditions.

6) **Ramp Dozer.** This unit is primarily used in confined areas that require wide to extra-wide swath plowing, but it may also be used to transport and dump snow. The ramp blade is equipped with side plates to contain snow and prevent spillage. Removal of the moldboard cutting edge allows the moldboard to act as a bucket for snow loading.

7) **Expressway Plow.** This type of plow provides the speed characteristics of a rigid plow and the clean-up ability of a reversible plow. The plow has bulldozing capabilities, and if horizontally adjusted, it has the ability to cast snow to the right or left.

8) **Vee Plow.** These plows are used for medium speed plowing operations through high drifts and heavy snow. Their acutely angled nose and swept wings will cast snow to the right and left simultaneously. In its articulated version, the plow operates at any angle along the arc of the wings from a fully closed "Vee" to one where the plow is extended to a near horizontal position.

b. **Side-Mounted Wings.**

1) **Extension Wings.** These attachments are mounted on either side of the carrier vehicle to increase the swath of the front-mounted plow. They are capable of high volume, high-speed snow removal operations.

2) **Leveling Wings.** These units operate with a front-mounted plow for windrow and snow bank leveling/trimming operations. The adjustable height of the leveling wing is designed to cast high drifted snow banks away from the cleared snow swath cut by the plow. They are designed for high-speed snow removal operations.

c. **Underbody-Mounted Scraper.** This unit is mounted behind the cab and on the underbody of a large truck or grader. During operation, constant ground pressure is applied by the scrapper blade on the pavement surface. The blade is capable of rotating its snow cast to either the left or right, thereby enhancing its ability to operate in confined areas.

19. **MOLDBOARDS.**

a. **Geometric Design.** The geometric design of a moldboard dictates the amount of snow that can be cast. A tapered moldboard or one with a flared end design or a moldboard that can change its contours will move larger amounts of snow higher and further than a moldboard of uniform height.

b. **Non-metal Moldboards.** Continuing development of non-metal moldboard materials may represent fuel savings because they are made of lighter weight polymers or other composites that will reduce snow/moldboard skin friction. Reductions in plow weights and skin friction reduce the power required to propel a snow plow unit, thereby reducing fuel consumption.

20. **SNOW DEFLECTOR SHIELD.** A snow deflector shield reduces snow spillage over the top of a moldboard by directing the air flow to the side toward the area of discharge. This helps to control the overhead snow plume created when traveling at high speed and thereby increases driver visibility.

21. **CUTTING EDGES.** Cutting edges may be made of either metal or nonmetal materials. Nonmetal cutting edges conform better to irregularities in pavement surfaces which result in reduced edge wear and noise. Tungsten tipped carbide cutting edges, on the other hand, have greater longevity, even under severe operating conditions. Only nonmetal cutting edges shall be used on pavements having in-pavement lighting.

22. **PLOW SHOES AND CASTERS.** The vertical separation between moldboard and pavement surface is determined by either plow shoes or caster wheels affixed to the moldboard reinforcing. These devices must be durable, reliable and able to perform without shimmy or damage to the pavement surface under all operating conditions. The design shall allow the shoes or wheels to be easily replaced. Shoes are inappropriate for use on surfaces containing in-pavement lights. Caster wheels are preferred in these instances because they permit more precise separations between the moldboard cutting edge and the paved surface. They also conform better to pavement irregularities, have a lower cutting edge wear ratio, and are less noisy.

23. **DISPLACEMENT PLOW/ROTARY PLOW RELATIONSHIP.** If heavy snow concentrations dictate a need for a rotary plow(s), the size and number of displacement plow(s) required to support the rotary plow may be determined through the use of figures 3-3 and 3-4.

24. **DISPLACEMENT PLOW SELECTION.** Guidance on the selection of displacement plows may be found in Chapter 6.

25-26. **RESERVED**

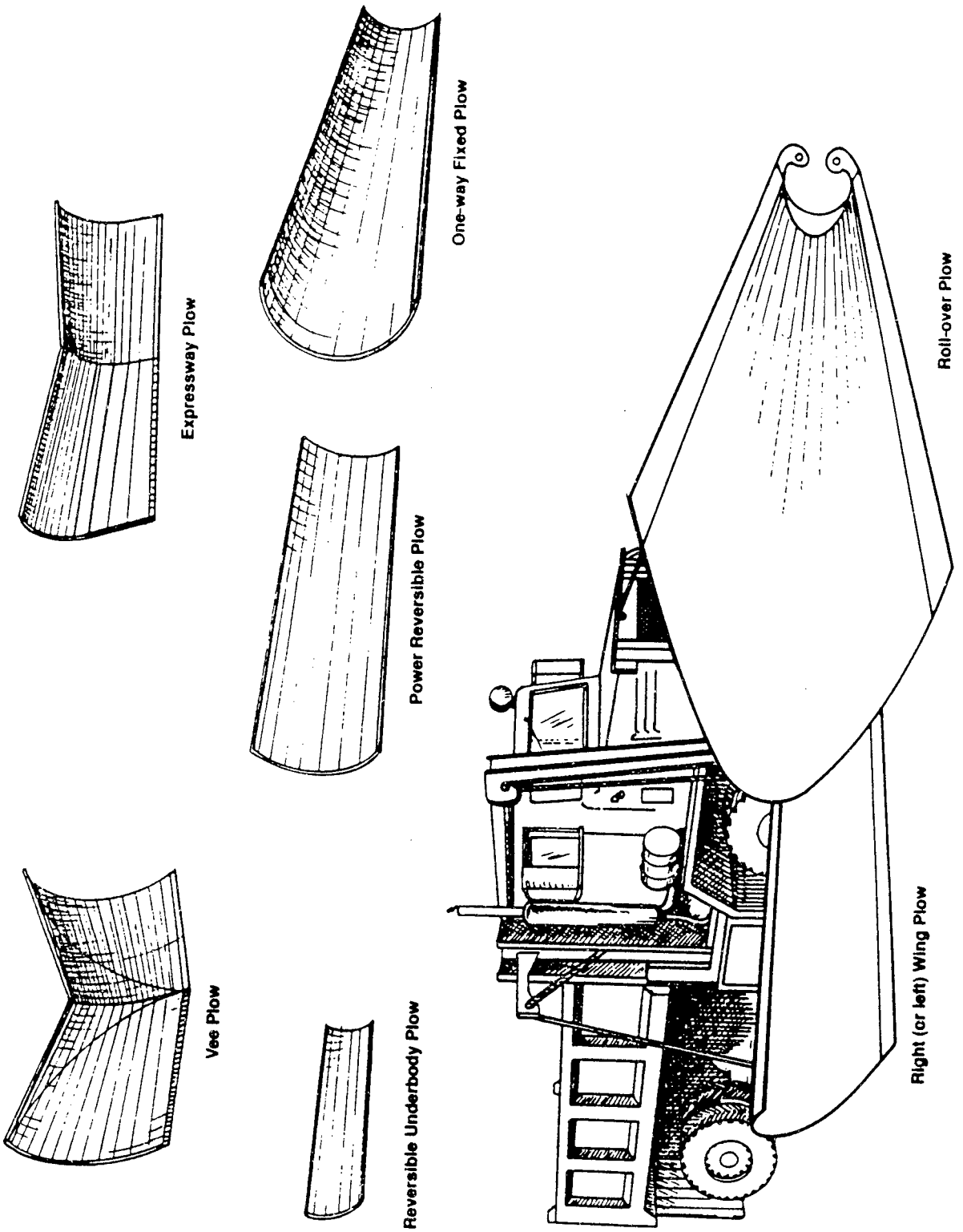


Figure 3-1. Different Types of Displacement Plows.

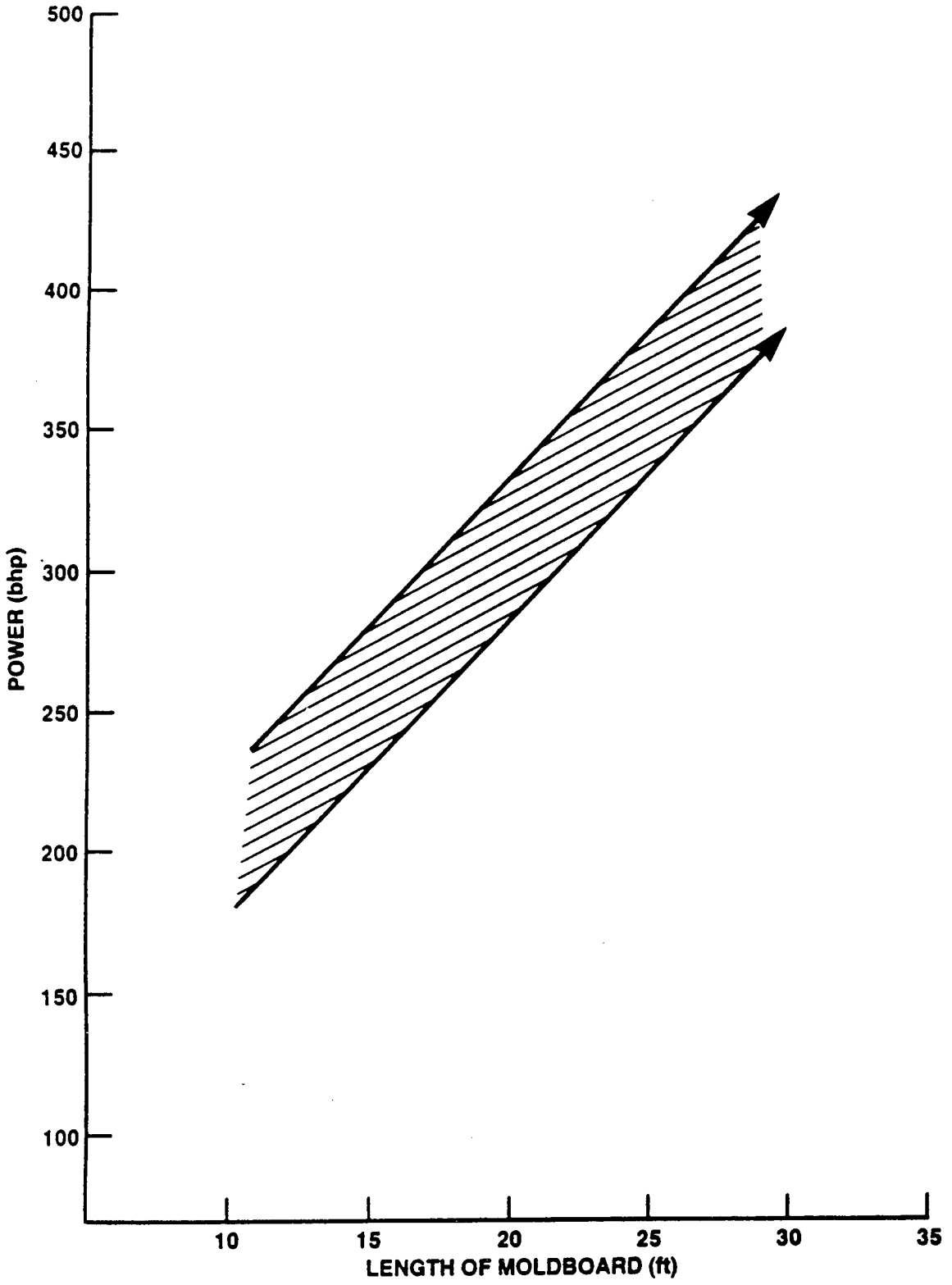


Figure 3-2. Carrier Vehicle Power versus Moldboard Length

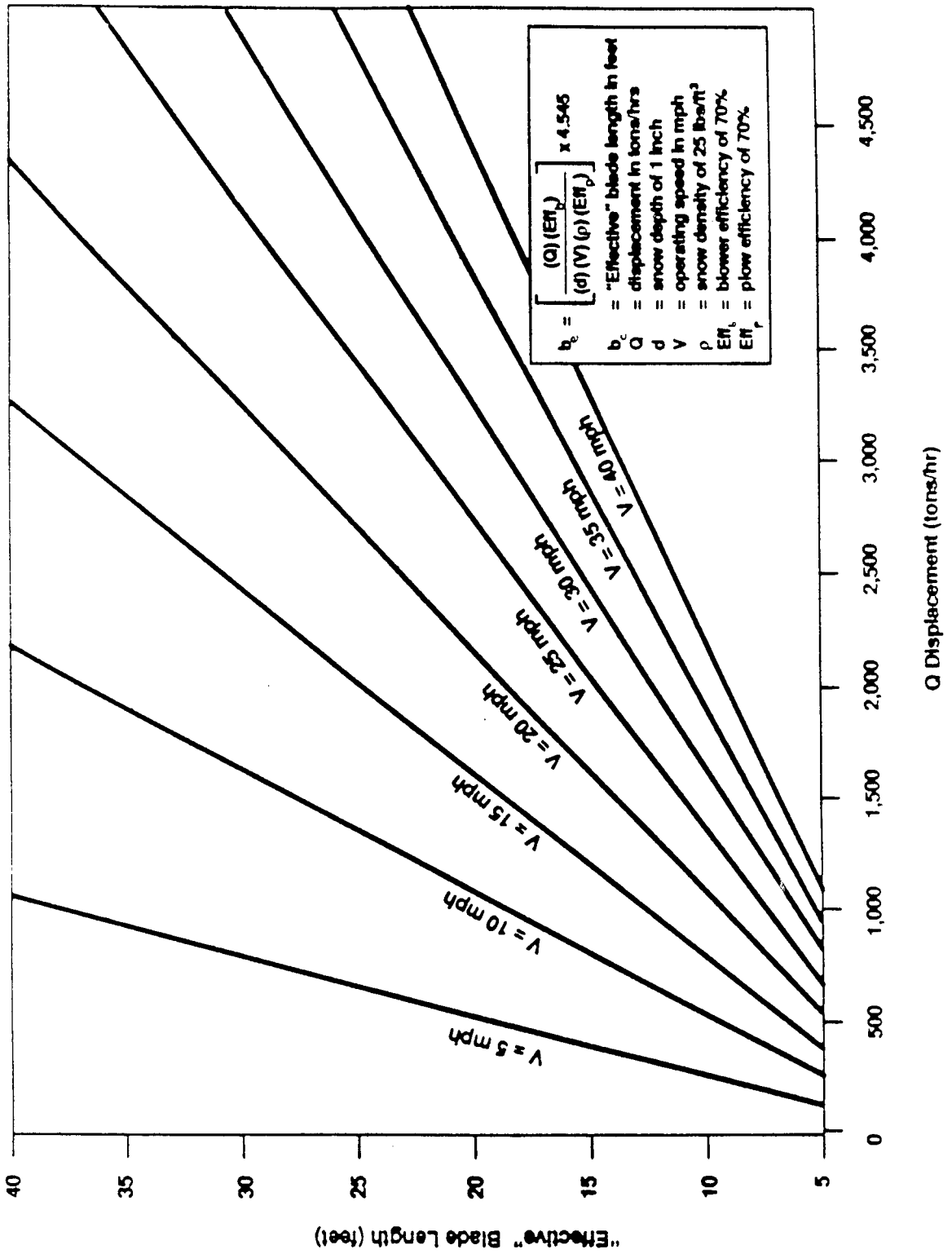


Figure 3-3. Effective Displacement Plow Blade Length Related to Snow Displacement

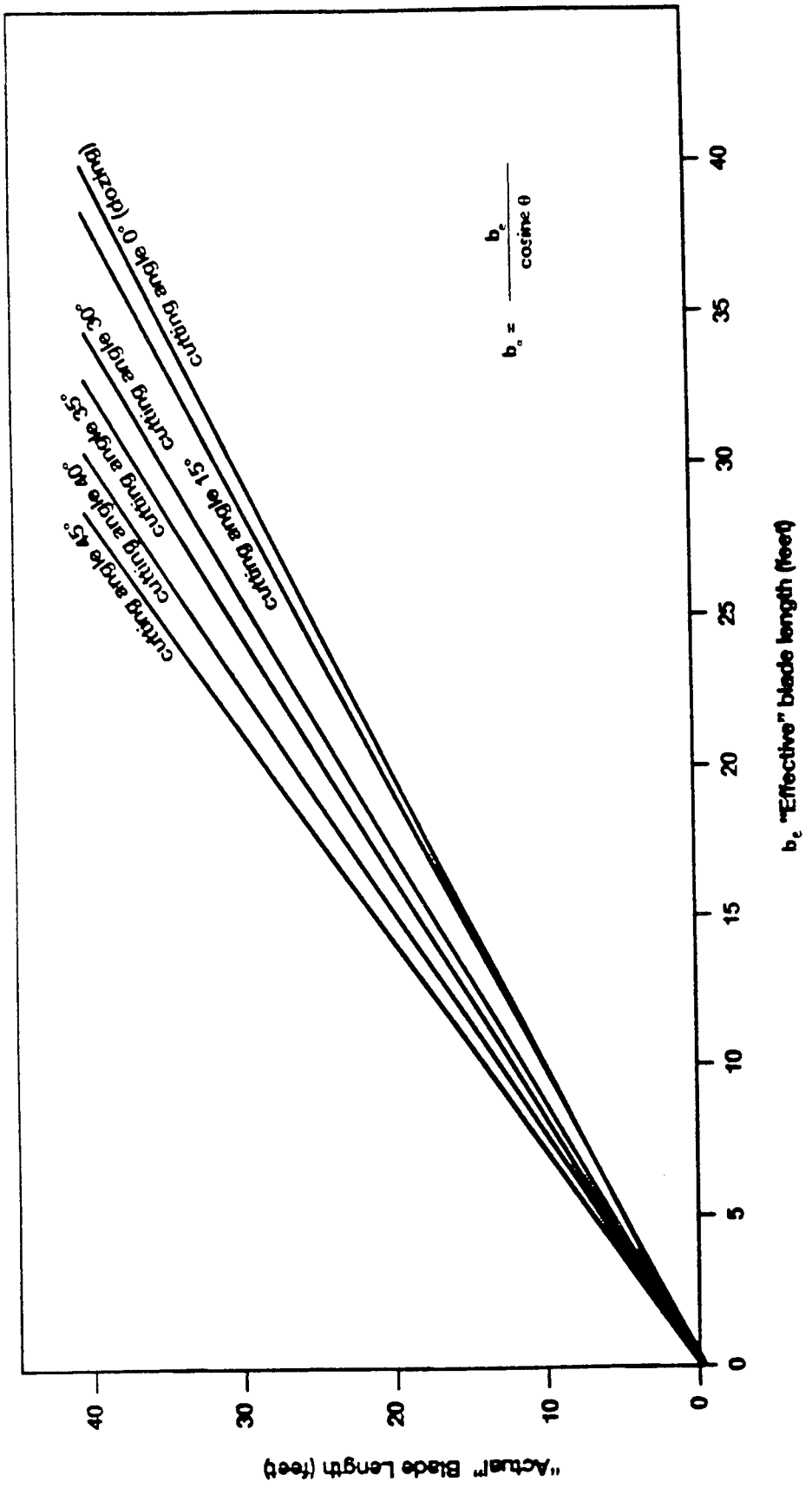
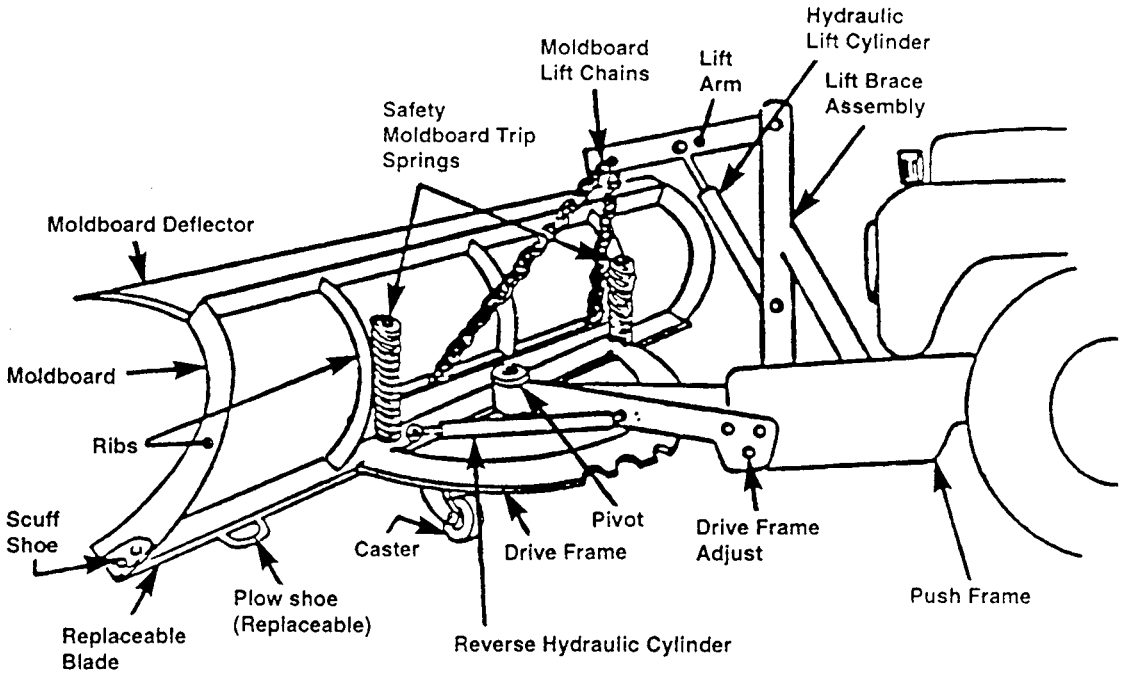


Figure 3-4. Effective versus Actual Displacement Plow Length



This Figure Illustrates a Power Reversible Plow With All General Components. Details of Plow Components May Vary With Plow Manufacturer & With Type of Plow

Figure 3-5. Displacement Plow Components

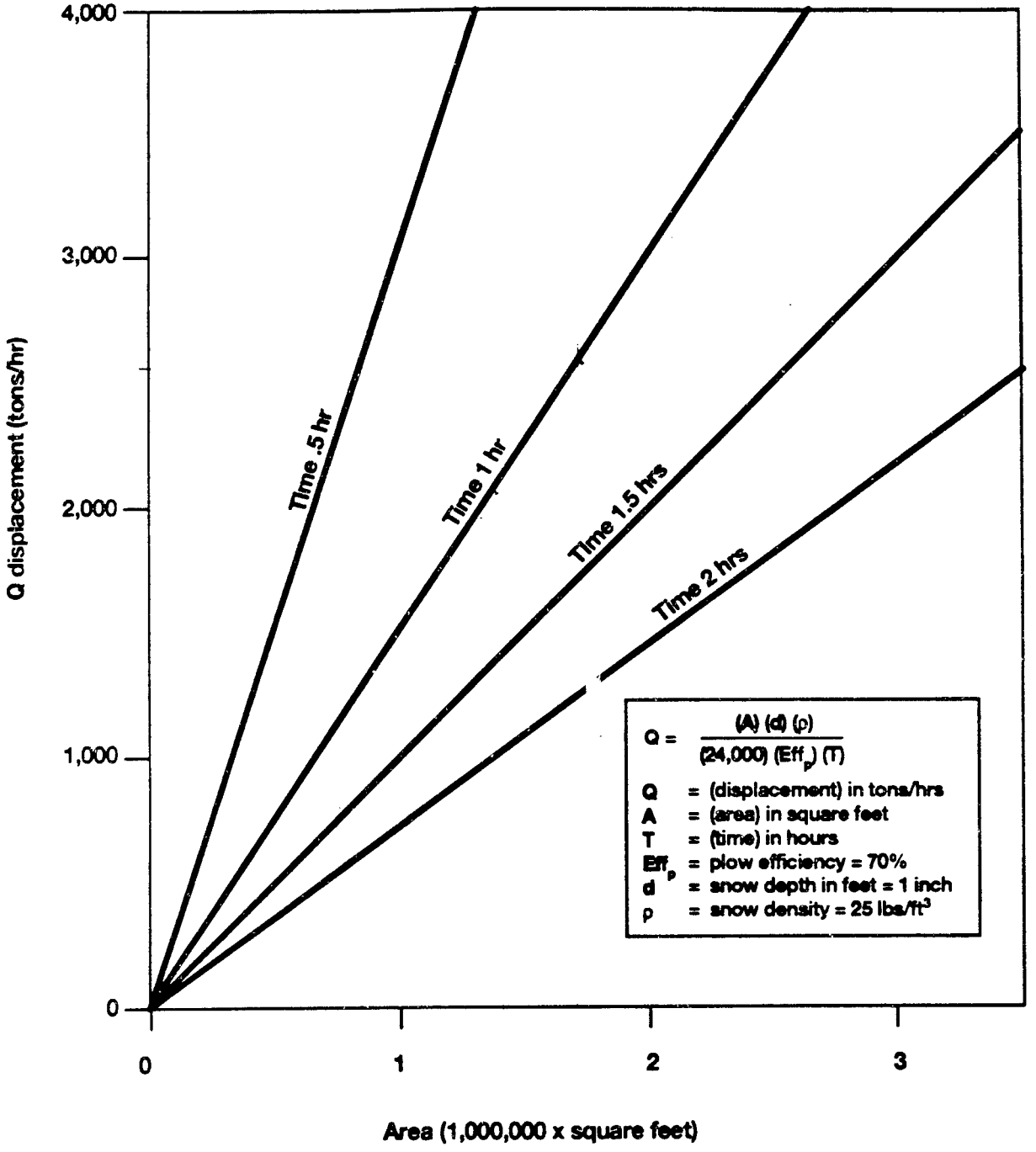


Figure 3-6. Snow Displacement (tons/hr.) Related to Surface Area

CHAPTER 4. MATERIAL SPREADERS

27. **DESCRIPTION.** The function of a material spreader is to provide a continuous, unrestricted, accurately metered flow of granular or liquid material to a pavement surface over a predetermined spread area. Spreader units may be self-contained or they may be attached to a carrier vehicle. A spreader unit consists of a material storage compartment, a feed mechanism to carry the material to the discharge opening, a metering device to control the discharge rate, and a distribution mechanism. Depending upon type, spreaders are capable of spreading dry and liquid chemicals and abrasives.

28. **TYPES OF SPREADERS.**

a. **Dry Material Spreaders.**

1) **Conventional Hopper Spreaders.** Chassis mounted or slip in type hopper spreaders mount longitudinally between or directly over the carrier vehicle frame members. Hopper capacities for 4x6 and larger vehicles range from 5 to 17 yd^3 (3.8 to 13.0 m^3). Hopper capacities for pickup trucks up to one ton are from 0.75 to 2 yd^3 (0.6 - 1.5 m^3). See figure 4-1 for typical dry material spreader types.

2) **Multi-Purpose Dump Body Spreader.** Multi-purpose dump body spreaders mount directly over the carrier vehicle frame members. The spreader may function as an elevating-dump body and as a material spreader. Hopper capacity shall be between 5 and 17 yd^3 (3.8 and 13.0 m^3).

3) **Tailgate Spreader.** Tailgate spreaders mount on or under the tailgate of an elevating dump body. Hopper capacity is determined by the capacity of the dump body.

4) **Towed Trailer Spreader.** A trailer spreader is towed by a separate vehicle but has its own frame and suspension system. These dry material spreaders have a hopper capacity between 6 and 10 yd^3 (4.6 and 7.6 m^3).

b. **Liquid Material Spreader.** Liquid material spreaders may be self-contained or mounted on a carrier vehicle. Fluids are applied to pavement surfaces via a spray applicator system consisting of a supply tank, pump, flow rate monitor, and a spray bar equipped with nozzles. Tank capacities range from 500 to 4,000 gallons (1 900 to 15 200 liters).

29. **DRY SPREADER SELECTION.** Dry material spreaders shall be selected based on hopper capacity and the ability to apply material to a surface area at a predetermined application rate. A conventional slide-on spreader is adequate for most airport applications of dry chemicals. Special requirements, such as a need to haul bulk sand from a supplier, may justify alternative or multi-purpose types of spreaders, e.g. a tailgate spreader coupled with a dump truck body.

a. **Hopper Capacity.** Hopper capacity is determined by the material or combination of materials to be spread, the rate of application, and the area to be covered. Once the area to be treated is identified, the operator must determine the critical materials to be spread in order to properly size the hopper. Figures 4-2, 4-3, and 4-4 show the weight/volume relationship among sand, airside urea, and CMA based on several application rates.

b. **Application rate.** Material manufacturers recommend application rates for these products. By simply entering the appropriate graph, using the desired area to be covered and a recommended application rate, the weight/volume relationship can quickly be determined.

c. **Example.** An operator intends to apply airside urea as an anti-icer to a 6000 foot (1830 m) by 75 foot (23 m) runway at a rate of 2.0 ounces/yd^2 (68 g/m^2). Later, sand is to be applied to the same runway at a rate of 4.0 ounces/yd^2 (136 g/m^2). What is the hopper capacity of the spreader needed to treat the runway surface, and what is the spreader body length required to accommodate this capacity?

Weight/volume Relationship of Sand and Urea

Abrasive	Weight of Material	Volume of Material
Sand	13,000 lbs.(5900 kg)	4.2 y^3 (3.8 m^3)
Airside Urea	6,200 lbs.(2815 kg)	4.9 y^3 (4.5 m^3)

In this case, the hopper capacity of the spreader should be at least 5.0 cubic yards to accommodate the critical urea material. The capacity chart below shows the standard inside spreader lengths necessary to accommodate volumes up to 17.2 cubic yards.

30. **LIQUID SPREADER SELECTION.** Application rates of de/anti-icer fluids vary depending on ice and snow accumulations and overall weather conditions. They may be as low as 0.30 gal/1,000 ft^2 (.01 l/m^2) when anti-icing or as much as 1.0 gal/1,000 ft^2 (.04 l/m^2) when de-icing. The size of the sprayer tank is a function of the square footage to be covered and the maximum fluid coverage rate to be applied. For example, assume that the critical primary surface area at an airport totals 700,000 ft^2 (65 000 m^2) and that the airport operator has determined that a fluid coverage rate of 1.0 gal/1,000 ft^2 (.04 l/m^2) will meet all but the most severe conditions with only one pass of the equipment. The minimum tank size needed would be:

700,000 ft^2 x 1.0 gal/1,000 ft^2 = 700 gals
(65 000 m^2 x .04 l/m^2 = 2 600 l)

Note: In selecting the size of a liquid spreader unit, the location of the storage tanks and the time it takes to reload the equipment with material must also be considered in the decision-making process.

31. **DESIGN AND COMPONENT LAYOUT.** The design and installation of accessories shall permit easy access for maintenance, cleaning, and service. All components and assemblies shall be free of hazardous protrusions, sharp edges, and cracks. Figure 4-6 illustrates design and component layout for a dry material spreader.

Table 4-1. SPREADER CAPACITY CHART

Vertical Height (inches)	Spreader Body Inside Length (feet)								
	8	9	10	11	12	13	14	15	16
48	4.5	5.1	5.6	6.2	6.8	7.3	7.9	8.4	8.9
54	5.5	6.2	6.9	7.6	8.4	9.0	9.7	10.3	11.0
60	6.5	7.4	8.3	9.0	9.9	10.7	11.6	12.2	13.0
66			9.5	10.3	11.5	12.3	13.5	14.2	15.1
72				11.9	13.0	14.0	15.3	16.1	17.2
	72	84	84	96	96	102	108	120	126
	Recommended Truck Cab to Axle Length, Inches								

32-33. **RESERVED.**

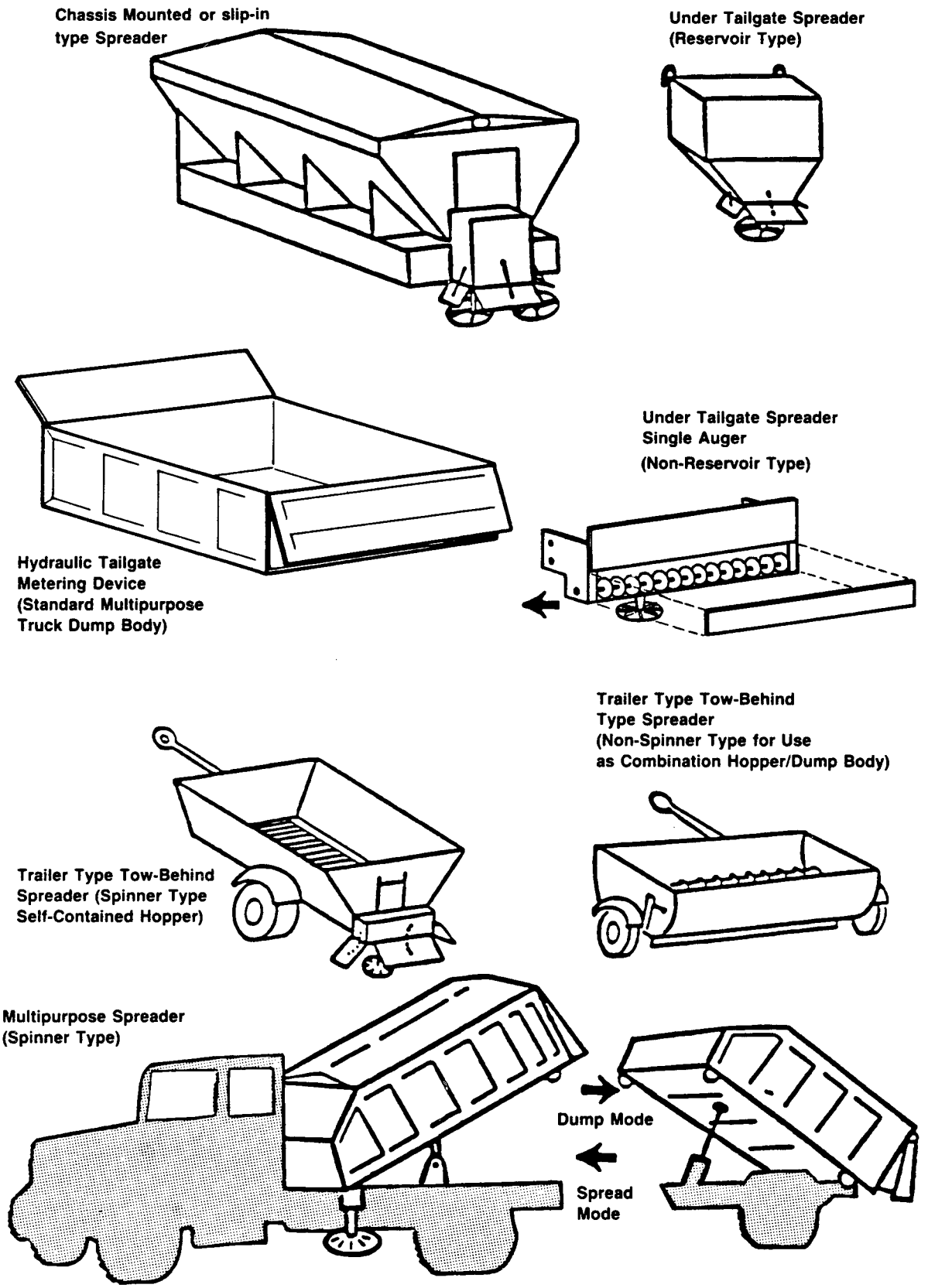


Figure 4-1. Dry Material Spreader Types

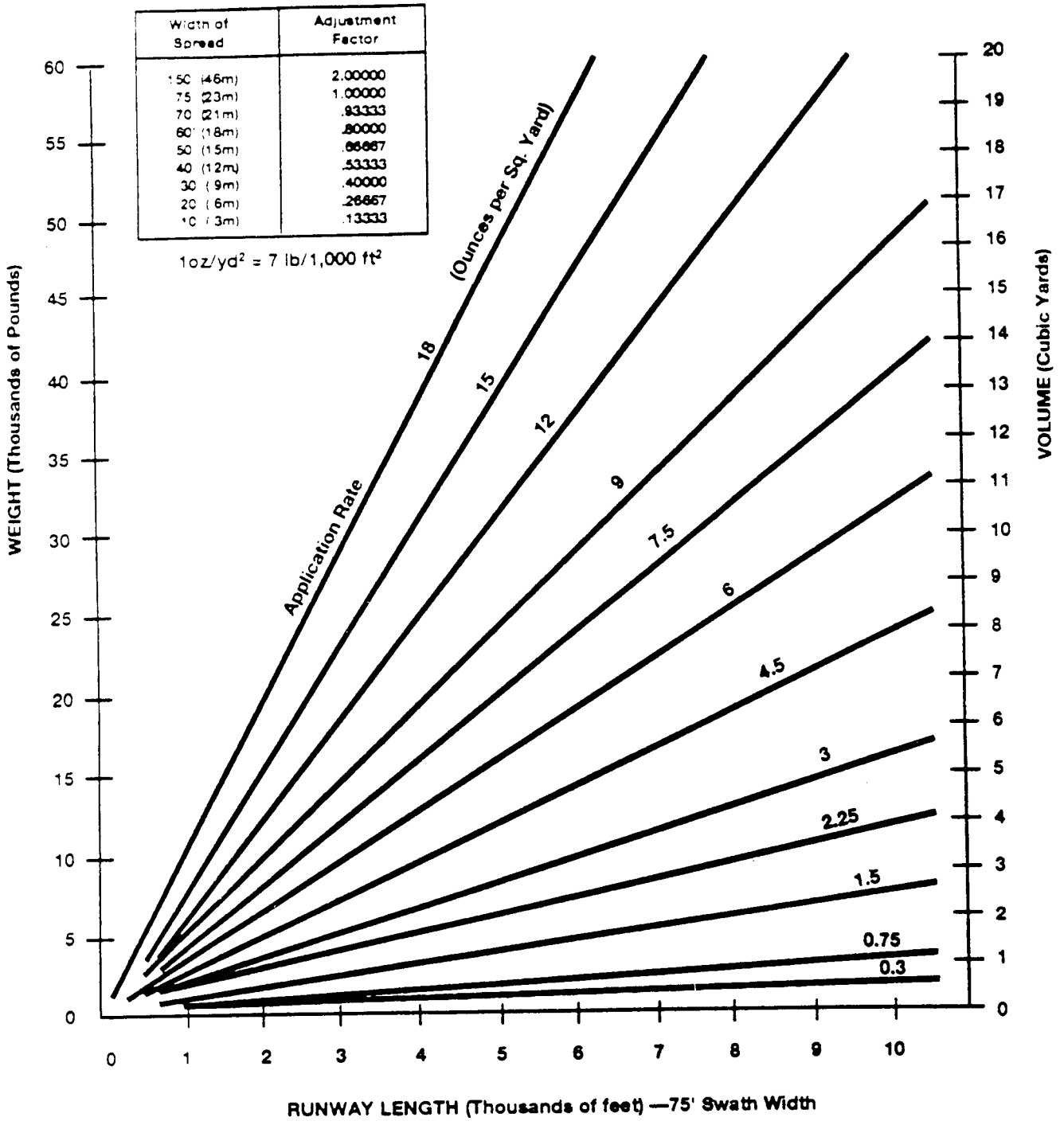


Figure 4-2. Hopper Capacity – – Sand

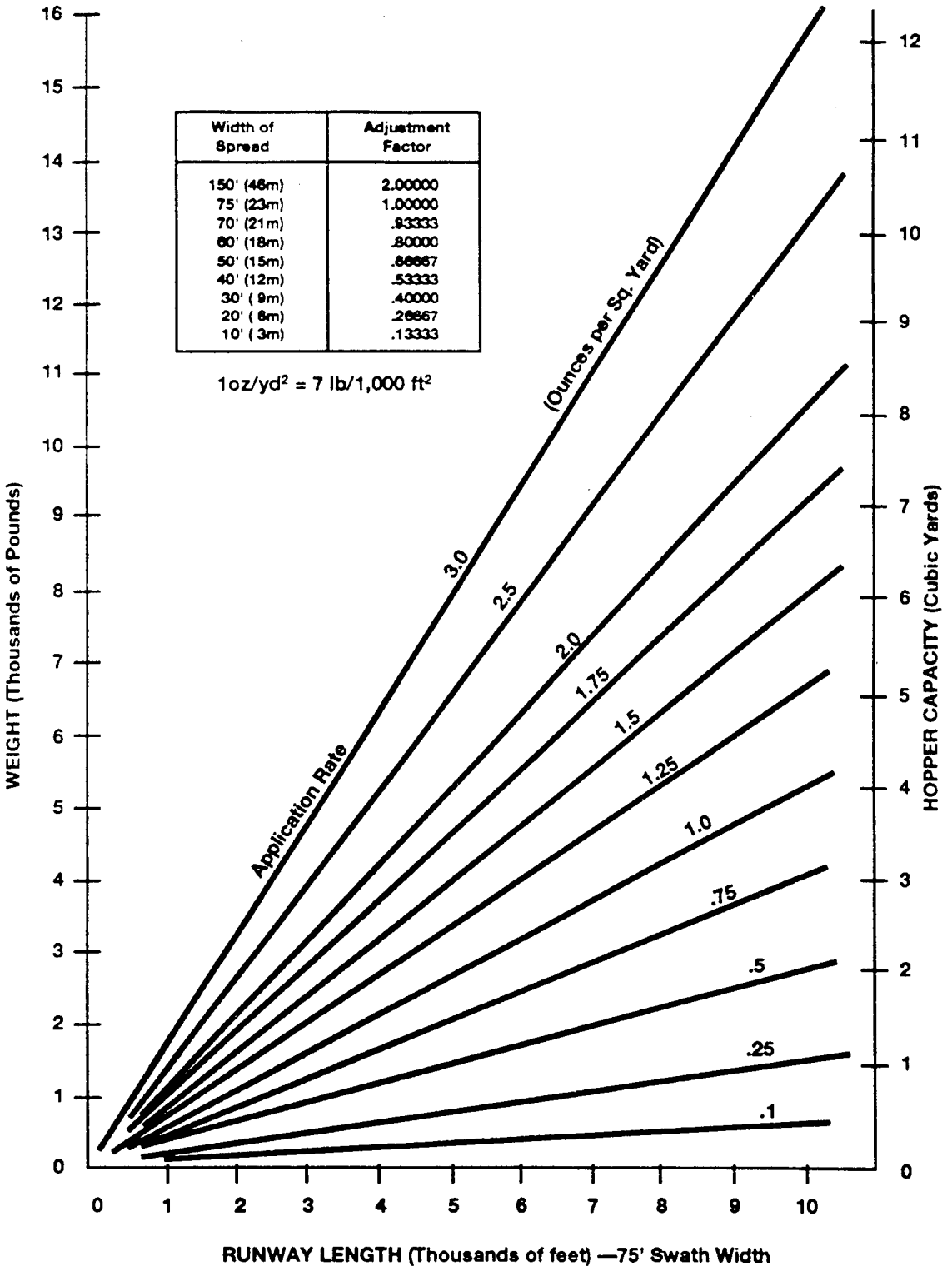


Figure 4-3. Hopper Capacity — Urea

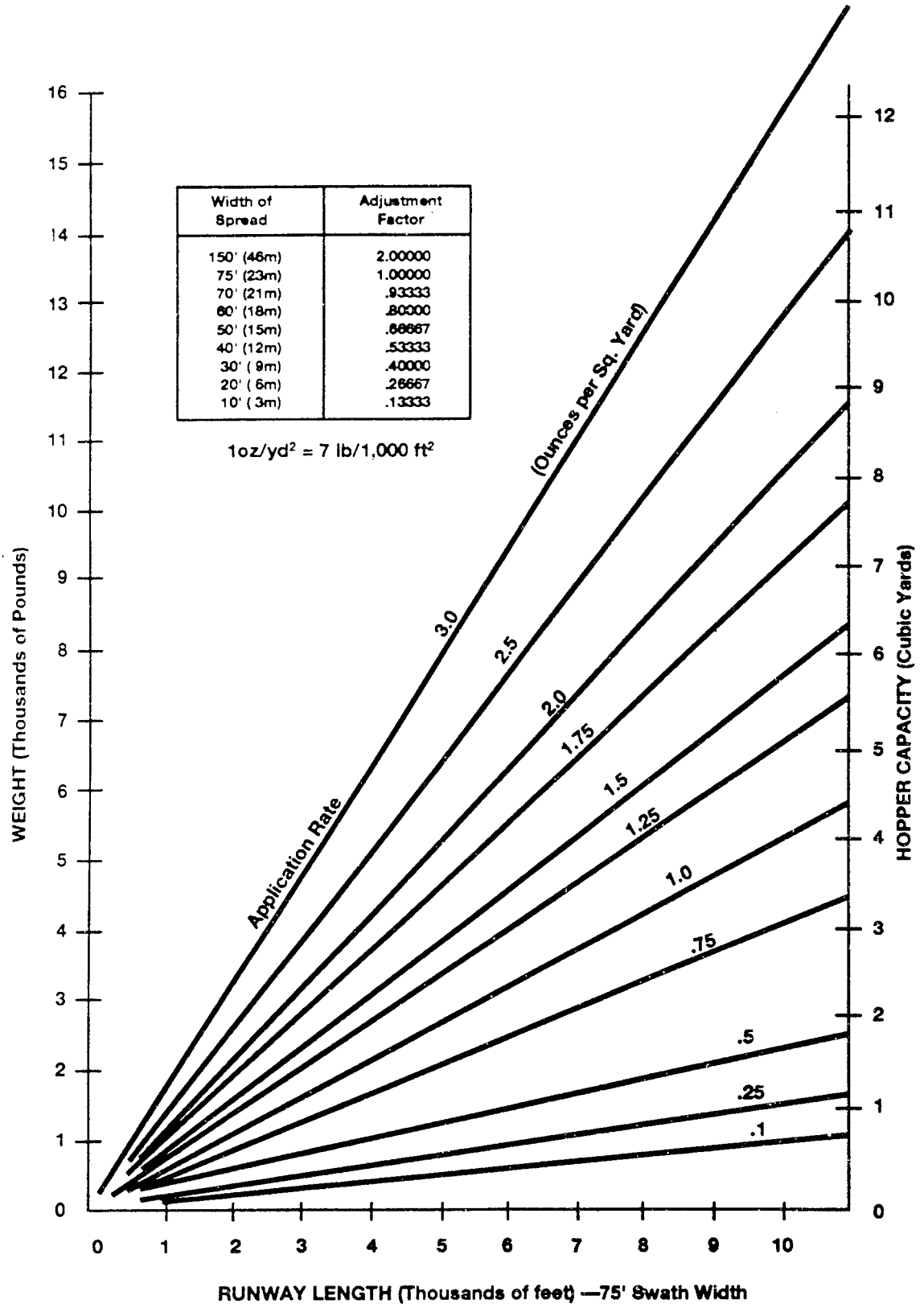
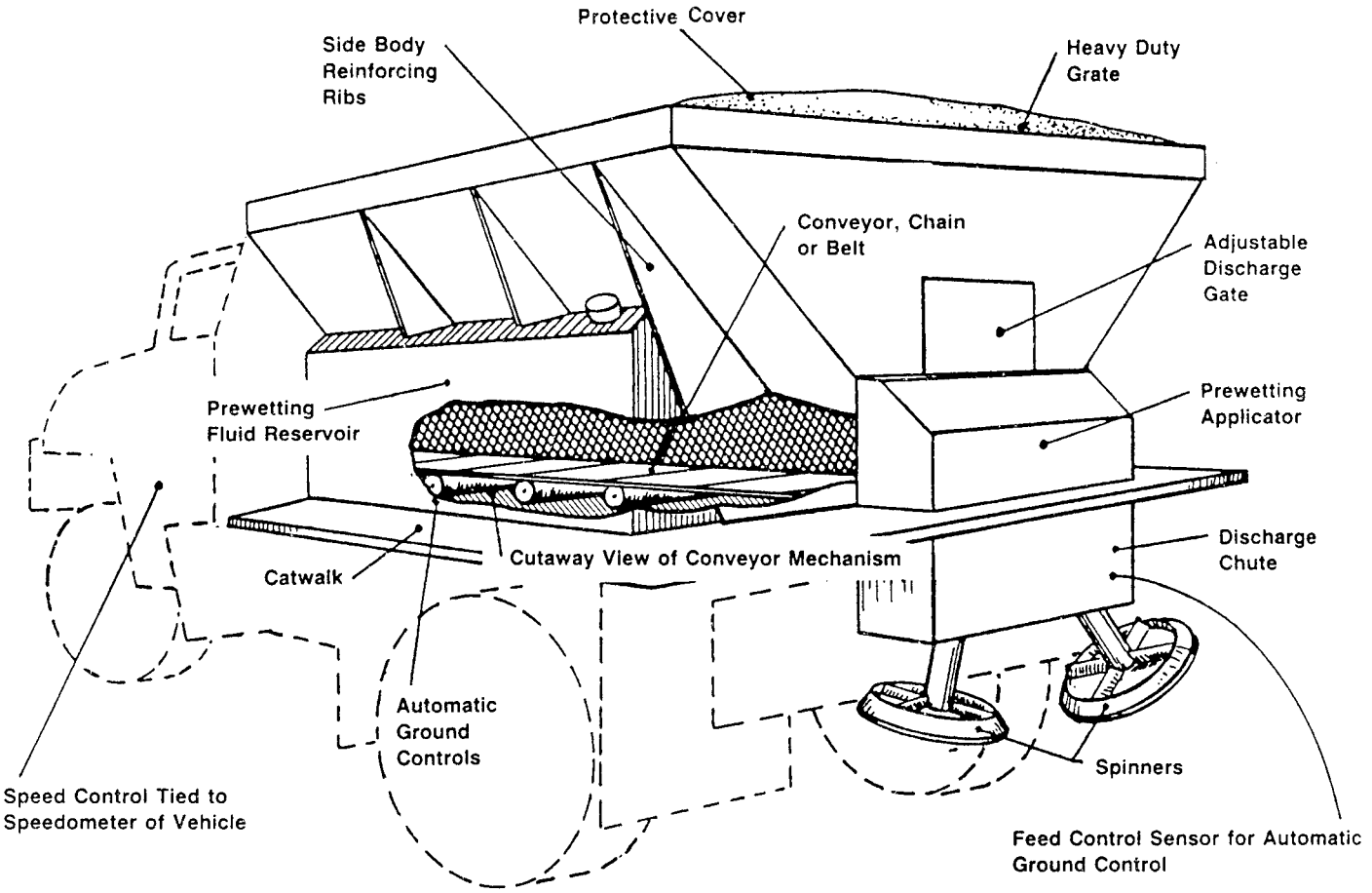


Figure 4-4. Hopper Capacity – – CMA



This figure depicts the general layout of a dry hopper system having a hydraulic or mechanical drive, a belt or chain type conveyor, and a dual spinner spreader. Some optional recommended devices are also depicted. Other spreader configurations may contain components differing in design, but essentially performing the same function.

Figure 4-5. General Design and Component Layout of a Dry Material Spreader

CHAPTER 5. CARRIER VEHICLES

34. **DESCRIPTION.** The term carrier vehicle represents the various self-propelled prime movers that provide the power necessary to move snow and ice control equipment during winter operations. Vehicle selection is determined by the mission to be performed and the capacity of the selected equipment.

a. **Truck Type Vehicles.** Truck type vehicles are standard production models designed primarily to meet an airport's snow and ice control needs but also have the ability to perform secondary functions. They may be self-contained, designed specifically for a singular purpose, or they may be multi-functional and equipped for several summer as well as winter tasks. They should conform to the manufacturer's recommendations and be suitable for mounting all specified accessories.

b. **Special Purpose Vehicles.** Special purpose vehicles are customized specifically to meet special airport needs such as high-volume and/or extra wide swath clearing operations.

c. **Wheel Loader Vehicles.** Wheel loaders are standard production four-wheel drive articulated and non-articulated vehicles, normally equipped with a front-mounted bucket, that operate at low speeds of 5 to 20 mph (8 to 30 km/h). They are very efficient for short haul operations and are used to clear compacted snow and ice from heavily used ramp and terminal areas and around pavement lights. A wheel loader will generally out-perform a truck-mounted displacement plow in such confined areas, but it is not as efficient when large open areas need to be cleared quickly. Other applications include snow loading and stockpiling and loading of solid chemicals and abrasives.

d. **Industrial 4x4 Tractor Vehicles.** Industrial 4x4 tractors are standard production models adapted for snow and ice control work in confined areas. While similar to wheel loaders, most are built to operate at higher speeds.

e. **Vehicle Dimension.** Vehicle dimensions shown in appendix 1 will permit vehicles to pass through the standard industrial door openings of service and storage buildings (AC 150/5220-18, Buildings for Storage and Maintenance of Airport Snow and Ice Control Equipment and Materials). These dimensions are also compatible with FAA recommended parking space set-asides within these buildings. Additionally, they should permit servicing of equipment by standard lifts and cranes without special equipment or building modification.

35-36. **RESERVED.**

CHAPTER 6. SELECTION OF ROTARY AND DISPLACEMENT PLOWS

37. **DESCRIPTION.** This chapter provides guidance in the selection of rotary and displacement plows under varying winter operational conditions. It is intended to familiarize the operator with the graphs and tables discussed earlier for use in determining displacement plow geometrics and rotary plow capacities. Several practical examples are discussed including a mathematical analyses that involves a number of variables including snow density, plow efficiency, and equipment speed.

38. MINIMUM EQUIPMENT REQUIREMENTS.

a. **Commercial Service Airports.** For commercial service airports that provide scheduled air carrier service and experience snow conditions as presented in AC 150/5200-30A, at least one high-speed rotary snowplow is recommended. This plow should be supplemented with at least two displacement plows having equal capacity. In addition to this equipment, for each 750,000 ft^2 (70 000 m^2) of primary pavement area, one towed or self propelled air-blast power sweeper and one hopper spreader for abrasives and solid de-icing chemical should be provided. If liquid de-icing chemical is used in lieu of, or in addition to, solid chemical, a minimum of one liquid spreader vehicle is recommended.

b. **Non-commercial Service Airports.** For non-commercial service airports having 10,000 or fewer annual operations and an annual snowfall of 30 inches (.76 m) or less, a minimum of one displacement plow should be provided. Airports having more than 30 inches (.76 m) of snow or those with over 10,000 operations and at least 15 inches (.38 m) of snow should have a minimum of one high-speed rotary plow supported by two displacement plows of equal capacity.

c. **Supporting Equipment.** Support vehicles such as sweepers and wheel loaders are usually needed to complete the removal of snow from all operational areas including secondary runways, taxiways, and ramp aprons.

39. **DISPLACEMENT PLOW/VEHICLE COMPATIBILITY.** A displacement plow must be properly paired with its carrier vehicle to achieve maximum operational performance. The level of performance between the two units is directly proportional to the type, size and weight of the plow and the power and weight of the vehicle. Figure 3-2, Carrier Vehicle Power versus Moldboard Length, provides a graphical representation of the vehicle power/displacement plow length relationship.

40. **SELECTING A ROTARY PLOW FOR COMMERCIAL AND NON-COMMERCIAL SERVICE AIRPORTS.**

In this example, an airport operator of a commercial service airport having an annual activity level of 35,000 operations wants to acquire a rotary plow for the upcoming winter season. Determine the size of the rotary plow needed based on the following conditions:

a. The airport snowplan calls for removal operations to begin when one inch of snow accumulates on the runway.

b. AC 150/5200-30A states that the primary surface area of this airport should be cleared in one hour.

c. Snow density is 25 lb/ft^3 (400 kg/m^3)-industry accepted standard.

GRAPHICAL SOLUTION

Step 1. Determine the size of the primary area to be cleared.

Location	Area
Main runway (9000 ft x 150 ft)	1,350,000 ft^2
Taxiways	187,000
Fillets	20,000
AARF apron and roads	20,000
Apron	40,000
Blast pads	60,000
Miscellaneous	20,000
Total primary area to be cleared	1,697,000 ft^2

Note: For calculation purposes, the area may be rounded off to 1,700,000 ft^2 (158 000 m^2).

Step 2. Use of Graphs.

Figure 2-5, Rotary Plow Calculations for Airports with Commercial Service, indicates that nearly 2,500 tons of snow per hour will have to be moved. Using either Figure 2-5 or Table 2-1, Rotary Plow Capacities, the following solutions are possible depending on the snow casting distance desired:

Class of plow	Casting Distance (ft/m)	No. plows needed
II	75/22.9	2
III	100/30.5	1

For non commercial airports, the same procedure holds, but the graph shown in Figure 2-4, Rotary Plow Calculations for Airports Without Commercial Service, should be used.

MATHEMATICAL SOLUTION

Figures 2-4 and 2-5 were developed from the following calculations and either procedure, graphical or mathematical, can be used in determining equipment selection. The mathematical solution is a little more flexible because it is capable of considering variables such as snow depth, snow density, and rotary plow efficiency that the graphical solution treats as industry accepted standards.

In this example, an airport operator of a commercial service airport prefers to clear the primary area in 40 minutes and needs to acquire a new rotary plow capable of casting snow at least 75 feet (22.9 m). The operator feels that local weather conditions are unique and that snow weighing 30 lb/ft^3 (480 kg/m^3) is typical. The operator also wants a rotary plow having an efficiency rating of 75 percent. What size rotary plow should be purchased?

Step 1. Determine size of area to be cleared (Use same procedure as step 1 above)

Step 2. Determine rate of snow to be cleared (tons/h).

Calculations

1,700,000 ft^2 x 1/12 ft = 141,666 ft^3
141,666 ft^3 x 30 lb/ft^3 = 4,249,980 lbs.
4,249,980 lbs 0.75 (eff.) = 5,666,640 lbs.
5,666,640 lbs. .67 h (40 min) = 8,457,672 lbs/h
8,457,672 lbs/h 2,000 lbs/ton = 4,229 tons/h

Step 3. Use of table 2-1

Snow removal requirements are approximately 4,300 tons per hour. Table 2-1 shows that several rotary plow combinations are possible. In this case, a Class IV rotary plow working in conjunction with a Class II plow is a possible combination. A single Class V plow is also a possibility, particularly since the required casting distance is only 75 feet (22.9 m). Obviously, there are several combinations that should be considered to assure the best use of equipment.

For non-commercial service airports, the mathematical procedure remains the same. The difference lies in the fact that the timing to clear the primary area of a commercial service airport is different from that of a non-commercial service airport. These times can be found in AC 150/5200-30A.

41. SELECTING A DISPLACEMENT PLOW BLADE LENGTH.

This section presents a graphical and mathematical procedure that may be used to determine the length of a displacement plow blade under various operational conditions. It should be pointed out that the process of selecting a plow blade is not an exact science and that different manufacturers may suggest alternative approaches tailored to their equipment, but the results should essentially be the same.

GRAPHICAL SOLUTION

Find the actual displacement plow blade length needed to clear one inch of snow in one hour from the primary surface area discussed above. Determine if the selected plow can be attached to an available carrier vehicle having 300 brake horsepower (bhp) which is designed to carry heavy front end loadings and if not, what are options available to the operator? The average operating speed of the plow unit must be at least 20 mph (32 kph) to meet the clearance times discussed in AC 150/5200-30A. The efficiency of the snowplow is 70 percent and the cutting angle of the blade will be set at 35°.

Step 1. Determine the size of the area to be cleared. (See step 1, para. 40 - graphical solution).

Step 2. Snow Displacement. Figure 3-6, Snow Displacement Related to Surface Area, shows that a snowplow working at a 70 percent efficiency level would have to displace about 2,500 tons of snow in one hour to clear the area.

Step 3. Effective Blade Length. Figure 3-3, Effective Displacement Plow Blade Length Related to Snow Displacement, shows that it would take an effective blade length of 23.0 feet (7.0 m) operating at 20 mph (32 kph) to displace 2,500 tons of snow in one hour.

Step 4. Actual Blade Length. In order to cut a 23.0 foot (7.0 m) wide swath with blade angle set at 35°, Figure 3-4, Effective Versus Actual Displacement Plow Blade Length, shows that a plow blade of 30.0 feet (9.1 m) would be required.

Step 5. Plow Selection. Figure 3-2, Carrier Vehicle Power versus Moldboard Length, shows that a vehicle having 300 bhp is only capable of accommodating a 18-23.0 foot (5.5-7.0 m) plow, depending upon plow and vehicle manufacture. At this point the operating official has several options available:

a) Acquire a carrier vehicle of about 400-500 bhp, figure 3-2, to accommodate the 30 foot plow. The 300 bhp vehicle would then be available for other purposes. This move would have to be carefully analyzed due to the size and cost of equipment involved and the cost of operation, or

b) Match the 300 bhp vehicle to a displacement plow of acceptable length (between 18-23.0 feet (5.5-7.0 m) say 20 feet (6.1 m) and acquire a second vehicle to accommodate the remaining 10.0 foot (3.0 m) blade still needed (30.0-20.0 = 10.0) (9.1-6.1 = 3.0 m), or

c) select any combination of possibilities that may or may not incorporate the 300 bhp vehicle.

MATHEMATICAL SOLUTION

The mathematical approach, similar to the one used earlier with rotary plows, provides flexibility in determining blade size because each variable is considered in the solution. In this example, an airport operator of a large commercial service airport wants to acquire a new displacement plow to more efficiently meet the capability of an existing 2500 ton rotary plow. For calculation purposes, the operator assumes the following local conditions:

CALCULATIONS

a. Snow accumulation (d)	1 inches
b. Snow density (p)	30 lbs/ft^3
c. Rotary plow capacity (Q)	2500 tons/h
d. Operating speed (v)	20 mph
e. Rotary plow efficiency eff(b)	70 %
f. Displacement plow efficiency eff(p)	75 %
g. Displacement plow cutting angle (a)	30 degrees

h. Conversion factor (4.545) = $\dfrac{12 \text{ in/ft} \times 2000 \text{ lbs/ton}}{5280 \text{ ft/mile}}$

i. Effective blade length (eb)

$$eb = \frac{Q \times Eff(b)}{d \times v \times p \; Eff(p)} \times 4.545$$

$$eb = \frac{2500 \times 0.70}{1 \times 20 \times 30 \times 0.75} \times 4.545$$

eb = 17.67 feet

j. Actual blade length (ab)

$$ab = \frac{eb}{\text{cosine a}}$$

$$ab = \frac{17.67}{\text{cosine 30}}$$

ab = 20.4 feet

K. Displacement plow selection. The airport operator would select a 21.0 foot displacement plow to support the 2500 ton rotary plow.

42-43. **RESERVED.**

CHAPTER 7. OPERATIONAL STANDARDS AND TESTING

44. **GENERAL.** The manufacturer shall be responsible for conducting tests to ensure that its snow and ice control equipment meets the operational and performance requirements it advertises. Certified records of these compliance tests shall be submitted by the manufacturer with each response to an invitation to bid. Equipment tests shall be conducted on standard production models and not on specially constructed prototypes.

45. **ADDITIONAL TESTS.** The purchaser should consider conducting its own operational, performance, and capacity tests on equipment prior to acceptance. The manufacturer should have the opportunity to witness the performance of these tests, but interpretation of results is the sole responsibility of the purchaser.

46. **CARRIER VEHICLE TESTS.** The following temperature, performance, and compliance tests may be conducted by a purchaser when acquiring a carrier vehicle.

a. **Cold Weather Operations.** A fully-equipped carrier vehicle should be able to perform normal operations at an ambient temperature of:

1) 10°F (-12°C) below the lowest temperature in which the vehicle is expected to operate, or

2) -40°F (-40°C) at airports located in extremely cold climates.

b. **Hot Weather Operations.** The vehicle should be capable of operating at an ambient temperature of 70°F (21°C) at the maximum speed recommended by the manufacturer without any of the vehicle components exceeding their normal operating temperature.

c. **Power.** Carrier vehicles shall have sufficient power to perform all operational and attached functions simultaneously.

d. **Performance.** The following tests shall be conducted on a vehicle loaded to its GVW (Gross Vehicle Weight) and shall include the following systems: hydraulic, power train, brake, lighting, controls, and instruments.

1) **10 Mile Test.** This test requires that the vehicle be driven over hard surfaced roads at normal airport speeds for a distance of 10 miles (16 km) with no perceptive problems. Special attention shall be focused on vibration, steering, vehicle drift, rattles, leaks, and interior controls.

2) **One Hour Test.** This is a time test that will be performed at a speed of 5 mph (8 kph) over all types of terrain that would normally be encountered at the airport.

3) **Service Brake Test.** This test shall be conducted at speeds of 20 mph and 40 mph (32 kph and 64 kph) respectively. Using the service brakes only, the fully loaded vehicle shall be brought to a complete stop within a distance of 35 and 131 feet (11 and 40 m) measured from the point of brake application. The test shall be conducted for two complete cycles in either direction on a hard pavement surface that is dry, reasonably level and free of loose material. During this maneuver, no steering corrections shall be made for vehicle drift during the stop.

4) **Emergency Brake Test.** This test shall be conducted at a speed of 40 mph (64 kph). Using the emergency brake only, the fully loaded vehicle shall be brought to a complete stop on the most critical airfield pavement grade within a distance of 288 feet (88 m) measured from the point of brake application. The test shall be conducted on a hard surface that is dry and free of loose material. Once stopped, the brake will continue to hold the vehicle without fade for five minutes. During this maneuver no steering corrections shall be made for vehicle drift during the stop.

47. **ROTARY PLOW TEST.** Rotary plow capacity and casting distance may be verified in the following manner:

a. **Preparation of Test.**

1) The testing official shall select a suitable site, preferably a flat, paved surface. A triangular shaped windrow made of fresh undisturbed snow shall be constructed on the site having a base of 10 feet (3 m) or a width conforming to equipment width (whichever is smaller), a minimum height of four (4) feet (1.2 m), and an average cross sectional area of at least 20 ft^2 (1.9 m^2). The snow density should be in the range of 25 to 30 lb/ft^3 (400 to 480 kg/m^3). The windrow should have a minimum length of 500 feet (150 m) and be made of relatively fresh snow that has not had an opportunity to melt or refreeze. Because the shear strength of snow changes with time, it is recommended that the test be started within one hour of windrow construction.

2) Equipment needed for the test is a 100 foot measuring tape, a thermometer, a stop watch, and a snow density measuring kit (Taylor LaChapelle or Kelly Snow Density Cutter).

3) During the test, the rotary plow should be operated at an engine temperature recommended by the manufacturer. The operator conducting the test should be familiar with the vehicle and the test procedure.

b. **Measurement.**

1) The cross sectional area of the windrow should be measured at the beginning, the end, and at 100 foot stations along the longitudinal centerline to ensure uniformity.

2) Snow density samples shall be taken at the base, middle, and top of these station locations. The average of their densities will become the average density of the windrow.

3) The test shall be run along the windrow in accordance with the manufacturer's recommended operating procedure to obtain maximum capacity and casting distance.

4) Capacity Calculations. The capacity of the rotary plow can now be calculated using the following formula:

$$Q = A \times L \times D \times 1.8/t$$

Where: Q = Capacity (tons/hour)

A = Average cross sectional area of windrow (ft^2)
L = Length of windrow (ft)
D = Average density of snow in lb/ft^3
t = Time of test run measured in seconds

c. **Casting Distance.** The casting distance is determined in accordance with guidance shown in Chapter 2, paragraph 12.

d. **Additional Visual Tests.** During the capacity tests, the rotary snowplow may also be visually evaluated. The swath that is cut should be even and regular and show less then 5 percent snow spillage.

48. **DISPLACEMENT PLOW CAPACITY TEST.** A displacement plow that is attached to a properly sized carrier vehicle, except for industrial 4x4 tractors and wheel loaders, should:

a. be capable of sustaining a speed of 25 mph (40 kph) on level pavement with plow angle set at 37° while negotiating a 3 to 6 inch (7.6 to 15.2 cm) snow accumulation having a density of approximately 25 lb/ft^3 (400 kg/m^3).

b. be able to discharge snow to either side of the vehicle while moving (if the unit is power reversible).

c. minimize snow spillover to 5 percent of total snow displaced.

d. be able to produce a clear swath that is even, regular and non-skipping.

e. be relatively free of blade vibration during operation.

49. **SPREADER TEST.** Material spreaders may be field tested to determine performance as follows:

a. **Liquid and dry spreader.** Liquid and dry spreader settings for swath width and application rate should be verifiable by field measurements to an accuracy of 2 percent under a no wind condition.

b. **Towed spreaders.** Towed spreaders should not vibrate excessively during operation and braking.

APPENDIX 1 - SPECIFICATION FOR CARRIER VEHICLE

PART A - AIRPORT OPERATOR CHECKLIST

FORWARD: When preparing a solicitation to purchase a carrier vehicle, an airport operator or specification writer should use PART A to identify user requirements and PART B to define the specification to meet these requirements. Part A is important because it tailors the carrier vehicle to the unique requirements of the purchaser, i.e. automatic versus manual transmission, gasoline versus diesel, grooved windshield versus plain etc. Both parts, when combined, become the technical basis for a users request for proposal.

1. **Anticipated uses and/or features of vehicle.** (Be Specific).....

.....

.....

.....

2. **Performance Requirements.**

   a. Required Working Speed.....
   b. Minimum Speed.....
   c. Turning Radius.....

3. **Engine/Transmission.**

   a. Automatic ..... Manual.....

   b. Gasoline ..... Diesel.....

   c. Number of forward speeds .....

4. **Transfer case.** (choose one)

   a. Single speed ..... Two speed .....

   b. Front axle disconnect .....
      Automatic locking differential .....
      Manual locking differential .....

5. **Axle capacities.** Front ..... Rear .....

6. **Fuel capacity.** ..... gallons

7. **Auxiliary equipment.** (see Appendix 2).....

.....

.....

PART B - SPECIFICATION FOR CARRIER VEHICLE

1. **MATERIALS.** Materials used on a carrier vehicle (vehicle) shall conform to the specifications listed in this advisory circular and appropriate sections of Title 49, Chapter III, Subchapter B - Federal Motor Carrier Safety Regulations (Title 49). When not specifically listed, materials shall be of the best quality available for their intended commercial use. Component parts shall be new and free of all defects and imperfections that could affect the serviceability of the finished product.

2. **DESIGN.** Equipment shall be developed in accordance with the best engineering practices available. This includes the incorporation of ergonomic designs specifically directed at the vehicles cab environment. Vehicle design shall include current state-of-the-art procedures that consider improved cab visibility, communications systems, interior lighting and the mitigation of noise and vibration. Design and installation of equipment shall permit easy accessibility for maintenance and service. All vehicle stress points shall be designed to distribute and dissipate shock forces.

3. **CONSTRUCTION.** Vehicle construction shall provide maximum protection against structural member failures. Equipment shall withstand the cold, moisture, strains, jars, vibration, and other conditions that are likely to be encountered during operation. All components and assemblies shall be free of hazardous protrusions, sharp edges, cracks, or other elements which might cause injury to personnel or damage to equipment. Location of all oil, hydraulic, and air lines and electrical wiring shall be in protected positions properly attached to the frame or body structure. Wherever these lines pass through structural members, they shall be protected with looms or grommets except where a through-frame connector is necessary.

4. **CHASSIS.**

a. **GENERAL.** The design of the vehicle chassis shall be based on an all-wheel drive concept for optimized performance and safety. It shall have power assisted steering and a transmission with suitable load ranges to accommodate normal operating conditions. A pintle hook shall be permanently attached to the rear frame structure capable of towing a vehicle. All installed parts and accessories necessary for the safe operation of the vehicle shall conform to applicable provisions of Title 49.

b. **Structural Members.** The frame shall be made of either pressed or structural steel channel and reinforced as required to prevent distortion under maximum load conditions. All frames and stiffeners shall be treated with a corrosion inhibitor and shall be primed and painted before assembly.

c. **Dimensions and Clearances.** Carrier vehicles shall have the following overall dimensions:

1) **Minimum Ground Clearance.** The minimum ground clearance of a vehicle chassis shall be 8 inches (20 cm).

2) **Maximum Overall Height.** The overall height of a vehicle excluding discharge chutes, lights, and exhaust stacks shall not exceed 13 feet (4.0 m).

3) **Maximum Overall Width.** The overall width of a vehicle including displacement plows at their maximum angle and wings folded shall be no more than 22 feet (6.7 m).

4) **Maximum Overall Length.** Maximum vehicular length should not exceed 35 feet (10.7 m).

5) **Minimum Turning Circle Diameter.** Using two wheel steering only, the vehicle must be capable of turning within a circle whose diameter is 100 feet (30 m). This diameter is measured from center to center of the outside front tire tread ground imprint.

e. **Weight Distribution.** The gross vehicle weight of the vehicle shall essentially be distributed equally over its axles. Under normal operating conditions, there shall not be more than a 20 percent variation in weight on any axle. The center of gravity shall be kept as low as possible under maximum load conditions. While it is loaded, the vehicle shall be capable of resting on a 20 percent transverse grade without danger of overturning.

5. **ENGINE.** The vehicle engine shall be of internal combustion, gasoline or diesel design having a minimum of four cylinders. It shall be able to meet the performance characteristics specified herein on commercial grade fuel. Dual engined vehicles shall use a common fuel. The engine shall develop sufficient torque and horsepower to meet its normal operational requirements without exceeding the no-load speed at the peak of its certified gross brake horsepower curve. Engine noise and vibration can be reduced in the vehicle cab by minimizing the number of engines for the various power requirements and by placing them behind or below the cab.

6. **COOLING SYSTEM.**

a. **General.** The engine cooling system shall be based on either a liquid or forced air design. Internal temperatures shall be controlled by a by-pass thermostat that regulates the flow of engine coolant. Even upon failure of the thermostat, the design of the system shall allow the engine to continue temporary operation without overheating. Drain cocks shall be installed at the lowest point of the cooling system and at other points necessary to completely drain the system.

b. **Coolant Temperatures.** Coolant temperatures shall not exceed 212°F (100°C) nor be less than 140°F (60°C) when operated in ambient temperatures during snow removal operations. In areas which frequently experience temperatures below -40°F (-40°C), cooling system heaters, oil pan heaters, lubricating oil heaters, battery block heaters, and vapor start systems are recommended (see Appendix 2).

7. **FUEL SYSTEM.**

a. **General.** The fuel system shall comply with Title 49 and be designed to eliminate the possibility of vapor lock. It shall include a carburetor or fuel injector, choke system (manual or automatic), fuel pump, fuel strainers, dry filter type air cleaners, fuel lines, valves, drains, and other accessories required to provide a complete operational system.

b. **Fuel Tank(s) and Lines.** Fuel tank(s) shall have the capacity to supply fuel continuously to the engine for a period of not less than 8 hours while it is operating at its rated horsepower under normal conditions. If dual tanks are used, the supply system shall be designed to ensure an uninterrupted flow of fuel to the engine. Fuel lines shall be securely fastened in place, installed to prevent chafing or strain, and protected by grommets where lines project through metal apertures. Each fuel tank is to be equipped with an accessible bronze or brass drain plug or a quick drain.

c. **Fuel Filler Pipe.** The fuel filler pipe shall be located in an accessible location outside of the vehicle cab. A light chain shall be attached near its opening and to the filler cap to prevent loss of the cap.

d. **Air Cleaner.** The air cleaner shall be of a two stage design. The first stage incorporates a centrifuging pre-cleaner while the second consists of a dry type replaceable paper filter. It shall display an indicator that shows when the dry type paper filter needs servicing. The connection between the air cleaner outlet(s) and the engine intake(s) shall be waterproof and dust tight. The air cleaner intake shall be positioned in a manner to discourage the ingestion of snow and other contaminants, e.g. within the hood cavity.

8. **EXHAUST SYSTEM AND MUFFLER.** The engine shall be equipped with an efficient and safe exhaust system including mufflers. Its location shall minimize noise and exhaust gases entering the vehicle cab under all operating conditions. Further noise reductions by noise suppression materials, such as muffler insulation, is encouraged. Horizontal portions of exhaust systems shall be protected, whenever possible, from corrosive agents and fuel spills. Exhaust systems shall be positioned under the vehicle in a manner to minimize contact with slush and snow. Muffler(s) are to be made of aluminum, stainless steel, or materials coated with ceramics. Devices shall be installed to prevent snow and slush from entering vertical exhaust stacks.

9. **GOVERNOR.** Engine speed shall be regulated by a governor set to provide the maximum operating speed recommended by the engine, driveline, and power train manufacturers.

10. **LUBRICATION.** An engine's lubricating system shall be equipped with standard production fittings and accessories. Engine oil filter(s) shall be of either full-flow or by-pass design with either able to accept commercial replacement elements. All engine(s) shall receive lubrication prior to delivery with lubricants designated for use under ambient temperature conditions at the point of delivery. The unit(s) shall be tagged to identify the proper lubricants and their temperature ranges.

11. **ACCESSIBILITY.**

a. **Component Location.** Engine and chassis components shall be positioned to allow easy access for inspection and maintenance purposes. Components that historically present maintenance problems or those that have the potential to cause operational problems should particularly be located in unobstructed areas. Locks, controls, and fasteners shall be designed to prevent over-torquing.

b. **Cover Plates.** Cover plates shall be equipped with either quick-disconnect fastenings or hinges.

12. **TRANSMISSION.** Transmission and vehicle manufacturers shall provide an application approval, at the time of vehicle delivery, that states the transmission is suitable for use in the vehicle as configured. The transmission shall operate smoothly and efficiently and be capable of transmitting the maximum gross torque generated by the engine to the drive wheels through all gear reductions. Drivetrains shall be in conformance with SAE requirements and shall be designed to minimize the number of joints. Transmissions may be either manual or automatic as follows:

a. **Manual.** This type of transmission shall have a clutch assembly rated to match the expected load ranges encountered under normal operating conditions. The gear selector shall clearly identify gear positions.

b. **Automatic.** Automatic or non-manual transmissions are either hydrostatic (with or without transfer case), automatic powershift, standard powershift, or fully automatic. Designs utilizing torque converters shall have a suitable torque ratio for the expected load ranges. The torque converter shall not operate at less than 70 percent efficiency. The gear or range selector shall have forward, neutral, and reverse positions clearly identified.

13. **TRANSFER CASE.** The vehicle and transfer case manufacturers shall provide an application approval at the time of vehicle delivery that states the transfer case is suitable for use in the vehicle, as configured. Transfer case assemblies shall provide positive drive to the front and rear axles and be of optional single or multi-speed design. Three proven alternatives are the manual front axle disconnect type, the center differential with manual or automatic lockout type, or an overriding clutch type, any of which may be selected by a purchaser as an option. The transfer case may be a separate unit mounted independently or integrated with the transmission.

14. **AXLES.** The axle and vehicle manufacturers shall provide an application approval at the time of vehicle delivery that states the front and rear axles are suitable for use in the vehicle, as configured. The axle manufacturer's published rating shall at the least be equal to the load imposed at ground level when the vehicle is at its rated gross vehicle weight (GVW). Each non-steering axle shall be equipped with a retarding type device to ensure a torque transfer to each wheel having traction. When appropriate, manual lockout controls shall be located in the vehicle cab. The torque capacity of each axle and differential shall be at least 10 percent in excess of the maximum torque that the axle may experience under any GVW operating condition. The power transmitting shaft on the front steering axles shall incorporate steering joints that do not produce objectionable steering characteristics while the vehicle is operating on uneven surfaces.

15. **BRAKE SYSTEM.** A vehicle service and emergency braking systems shall meet Title 49 requirements for vehicles of similar design. These systems, whether air, hydraulic, or of another design, shall be complete with all necessary equipment to safely control, stop, and hold a fully equipped vehicle under all normal operating conditions. Both systems shall be readily accessible for external adjustment.

16. **STEERING MECHANISM.** The vehicle shall have a hydraulic or power assist steering mechanism which is operated from the driver's seat. During normal operations, the mechanism shall be capable of controlling the vehicle with all equipment operating. The design of the steering mechanism should, in the event of a power assist failure, be capable of safely bringing the vehicle to a park position from the maximum design speed allowed on the airport.

17. **SUSPENSION SYSTEM.** Vehicles shall be equipped with a current production model suspension system having a minimum rated capacity equal to the GVW of the carrier vehicle. System capacity may be determined by taking measurements from ground level with the vehicle loaded to its rated GVW and the attached equipment in its storage position. When required, front and rear axles shall have auxiliary suspension springs. Manufacture's capacity ratings may not be raised to conform to the requirements of this specification. The suspension system shall exhibit no permanent set after the load is removed.

18. **WHEELS, RIMS, TIRES, AND TUBES.**

a. **Wheels.** Rim and tire ratings shall conform to The Tire and Rim Association's published recommendations.

b. **Tires.** Each tire shall have a rated carrying capacity at least equal to the loads imposed on them by a fully loaded vehicle measured at each wheel. Tires on each axle shall be of the same size, except where dual tires require different sizes, and they shall have an aggressive tire tread. Tires (and tubes when applicable) shall meet the first line commercial grade requirements for the speed and type of service required. The front and rear tread widths shall not vary by more than four percent.

c. **Spare Rim/Tire.** Each rubber tired vehicle shall be equipped with a spare rim and tire set. If the vehicle possesses two or more separate and distinct tire and wheel sizes, the vehicle manufacturer shall provide one rim and tire set for each size.

19. **HYDRAULIC SYSTEM.**

a. **General.** The hydraulic system shall consist of appropriate rams, pumps, piping, fittings, valves, controls, fluid reservoirs and filters, coolers, and other parts essential to its full operation. The system shall be capable of hydraulically positioning equipment through the entire range of its design limits. It shall be capable of operating all controls simultaneously without a noticeable reduction in power response. All hydraulic controls shall be located in the vehicle cab. The system shall be ruggedly constructed and able to withstand all loads imposed on it without relying on the use of mechanical locks. Filters within the hydraulic system shall conform to the Society of Automotive Engineers (SAE) Information Report, SAE J 931- Hydraulic Power Circuit Filtration.

b. **Pump and Power Takeoff.** The pump shall be ruggedly constructed and powered by the engine through a crankshaft power takeoff. It shall have sufficient capacity to operate the hydraulic equipment specified herein under all operating conditions and speeds.

c. **Lines and Fittings.** Only commercial quality hydraulic lines, hoses, and fittings that are capable of withstanding system working pressures under load are acceptable. Hydraulic hoses shall have a bursting pressure of three times their rated working pressure. The use of fittings, joints, and connections shall be kept to a minimum.

d. **Fluid Tank.** The hydraulic fluid tank shall have a filler neck consisting of a strainer, drain plug, shutoff valve, air vent, and baffles. Its capacity shall exceed the volume of oil required for the operation of any combination of attachments by 50 percent, and it shall have a hydraulic fluid quantity level measurement.

e. **System Winterization.** The hydraulic system shall meet the same low temperature requirements as the engine coolant system.

20. ELECTRICAL SYSTEM.

a. **General.** The electrical system shall be negatively grounded and installed in accordance with current state-of-the-art practices and appropriate Federal requirements. All parts of the electrical system shall be waterproof, easily accessible, securely mounted, and protected against extreme temperatures, physical damage, snow, oil, and corrosion. All electrical circuit wiring shall be made of stranded conductors with a capacity exceeding the anticipated maximum circuit loading. Insulation of electrical wiring shall be equal to the recommended standards established for insulation materials by the Society of Automotive Engineers (SAE).

b. **Power Supply.** The carrier vehicle shall be equipped with a self regulating electric alternator having an output capacity that exceeds the anticipated electrical load.

c. **Batteries.** Batteries shall be securely mounted and adequately protected against physical injury, water, chemicals, and exhaust heat. They shall be properly sized based on vehicle manufacturer recommendations and be readily accessible for changeout and for other purposes. Enclosed battery compartments shall have adequate ventilation. Battery capacity (cranking amps, voltage, reserve power, continuous/deep cycle demand) shall be compatible with the size of the engine and the anticipated electrical load expected under normal operating conditions. Minimum battery size to start the engine shall be rated at 120 ampere-hours over a 20-hour discharge rate.

d. **Starting Device.** The vehicle shall have an electrical starter that shall not introduce a voltage drop sufficient to affect adversely the ignition system. It shall be equipped with an overload protection device. One of the following electrical/starting systems shall be provided:

1) 12 volt electrical and starting.

2) 12 volt electrical/24 volt starting.

3) 24 volt electrical and starting.

e. **Ignition System.** Ignition systems for gasoline engines shall be of either electronic or distributor and coil design. Diesel engines may be equipped with or without glowplugs, depending on make, model, and manufacturer. Under extreme weather conditions, a block heater should be considered for improved ignition.

f. **Sounding Device.** Excluding pick-up trucks, each vehicle shall be equipped with an audible sounding device that is activated when the vehicle is shifted into reverse gear.

21. LIGHTING SYSTEM. The lighting system, including reflectors and clearance lights, shall be standard equipment currently used by the manufacturer. Task-oriented lights should be capable of lighting those areas to be cleared. The system shall include:

a. **Headlights.** The carrier vehicle shall be equipped with two or more sealed-beam quartz-halogen or equivalent headlights with upper and lower driving beams and a foot or hand controlled switch for beam selection. Snow removal attachments and other accessories should not be positioned so as to obstruct the illumination of these lights.

b. **Dual Tail lights and Dual Stop lights.** Each vehicle operating on airport property shall be equipped with dual tail lights and dual stop lights. The stop lights shall be activated whenever service brakes are applied.

c. **Turn Signals.** The carrier vehicle shall be equipped with two front and two rear turn signals that conform to SAE Turn Signal Units, Type I Class A, with self-cancelling controls and a visual/audible indicator. In addition to signalling turning movements, the system shall also be capable of signalling a hazardous condition by flashing simultaneously with the ignition of the vehicle turned on or off.

d. **Spotlight.** There shall be a corrosion resistant spotlight securely mounted on the cab roof. It shall be operable by hand from within the cab.

e. **Reflectors, Markers, and Clearance Lights.** This equipment shall conform to the requirements of Title 49. The clearance lights shall have commercial truck lenses.

f. **Engine Compartment Lights.** These lights shall adequately illuminate both sides of the engine(s). Location of the switches shall be in the engine compartment(s) with proper clearances so that they can be activated by operators wearing heavy winter gloves and outer garments.

g. **Backup Lights.** There shall be at least two backup lights installed at the rear of and at either side of the vehicle that will automatically be activated when the vehicle is shifted into reverse gear.

h. **Vehicle Safety Identification Lights.** The vehicle shall have a minimum of one revolving yellow beacon mounted on its uppermost part (see AC 150/5210-5B, Painting, Marking, and Lighting of Vehicles on an Airport). The light emitted from the beacon should not reflect off rearview mirrors and into the operator's eyes. The beacon shall be steady burning with the following characteristics:

1) low-intensity lighting with an upper limit of 400 candelas (effective) to avoid damage to night vision. The minimum effective intensity range in the horizontal plane should be at least 40 candelas but not more than 400 candelas.

2) 360° azimuth (horizontal) coverage.

3) peak intensity from 0° to 10° above the horizontal and reduced intensity to 1/10 of peak intensity from 10° to 15° above the horizontal.

22. **OPERATOR'S CAB.**

a. **General.** Carrier vehicle cabs shall be made of either metal or fiberglass construction and be of conventional, cab forward or cab-over design. They shall be fully enclosed accommodating a single operator only (half cab) or single operator plus assistant/trainee (full cab). A definite separation shall exist between the engine and operator's compartment. All non-glass surfaces, such as the floor, sides, and roof of the cab, shall have insulation to reduce exterior noise. The maximum interior cab noise measured at the operator's seat shall not exceed 85 dBa under the following conditions: windows closed, heater and defrost systems at maximum operation, and carrier vehicle and equipment engines operating at maximum rated capacity. To the extent possible, the interior of the cab shall be ergonomically designed providing the operator with a pleasant working atmosphere that is devoid of the stark conditions normally associated with older equipment.

b. **Communications Equipment Space.** Transceivers shall be installed in carrier vehicles to establish voice communication with other vehicles, the air traffic control tower, snow control center and maintenance facilities. The vehicle cab shall be designed to provide convenient space near the operator for the installation of a pair of transceivers.

c. **Fire Extinguisher.** The vehicle cab shall have at least one 2A-10BC interior mounted fire extinguisher that is readily accessible to the operator.

d. **Operator Seat.** The vehicle cab shall provide an operator seat that can easily be adjusted up and down, fore and aft, a minimum of three inches (7.6 cm) in each direction. The seat should also be capable of reducing the effect of vehicle vibration by featuring air-cushion shock absorbing seat systems or systems of comparable design. All vehicle seats shall have approved seat belts. Seats shall be fully upholstered with a good quality fabric or plastic material.

e. **Windows.** The vehicle cab shall maximize the use of glass, including the placement of panels if possible in the lower sections of door panels, to increase the operator's view of operational areas and ground surfaces. All installed glass shall be laminated and safety rated. The location and size of the windshield shall minimize visual obstructions to the operator. The windshield shall be designed to avoid snow buildup and be equipped with at least one two speed automatically operating wiper (standard or wet) that is capable of sweeping a clear view for all occupants. The windshield washer reservoir shall have a capacity of at least one-half gallon (2 liter). Fluid applicators shall be located to provide at least 75 percent coverage to the windshield. The cab shall be equipped with sun visors.

f. **Exterior Rearview Mirrors.** Two electrically heated exterior rear view mirrors of the extension arm type shall be mounted on each side of the vehicle cab. Each mirror shall have an area of not less than 100 in^2 (650 cm^2).

g. **Heater-Defroster.**

1) **Heating System.** The carrier vehicle cab shall have a heating system that is capable of maintaining a minimum interior temperature of 65° F (18° C) at an ambient outside temperature of -20° F (-29° C). Heat output shall be controllable from within the cab by a selector switch that is conveniently located to the operator. Under all conditions of heating and ventilation, the temperatures measured in the operator's immediate environment should be uniform within 9° F (5° C) (see SAE J 1503, Performance Test for Air-conditioned, Heated and Ventilated off-Road Self Propelled Work Machines).

2) **Windshield.** Windshields and other glass surfaces in the vehicle cab used in the operation of the vehicle and or to view pavement surfaces, including rear windows if installed, shall be defrosted through a heat energy transfer system.

h. **Ventilation.** Each vehicle cab occupant should receive a minimum of 25 ft^3/m (.71 m^3/m) of filtered fresh air under all heating and ventilating conditions (see SAE J 1503). Cab ventilator intakes should be screened and positioned in such a manner to minimize the entry of snow.

i. **Hourmeters.** Every engine permanently attached to a carrier vehicle shall be equipped with an hourmeter that registers engine operation time from zero to 9999 hours. Hourmeters shall be prominently displayed so that they can be easily read by an operator or service personnel. The hourmeters shall be of direct read design and shall only register when the engine is running.

j. **Instrumentation.** The cab shall display an instrument panel equipped with rocker and/or toggle switches and controls (instruments) that are user friendly to operators wearing bulky winter clothing. Toggle switches, where used, shall have a minimum length of 1 1/2 inches (4 cm). Frequently used instruments shall be located in direct line-of-sight and within forearm reach of a medium-sized person sitting in the operator's position. All instruments shall be clearly identified with labels that indicate their function. Instruments should display urgency-of-action lights, i.e., green for normal operation, amber for warning, and red for emergency. Instruments shall be illuminated by background lighting regulated by dimmer switches capable of providing infinitely variable lighting intensities. Circuit breakers shall be grouped for easy access and convenience. Typical instruments that report and track major functions of a carrier vehicle are as follows:

1) **Engine.**

a) **Voltmeter.**

b) **Lubricating Oil Pressure Gauges.**

c) **Coolant Temperature Gauge(s).**

d) **Tachometer(s) including hourmeter(s).**

e) **Starting Controls** (including auxiliary cold start controls).

f) **Hydraulic Oil Pressure and Temperature Gauge** if applicable.

2) **Vehicle Chassis.**

a) **Brake-air Pressure Gauges** if required.

b) **Low-air Pressure Warning,** visual and audible type if required.

c) **Light Switches and Headlight Beam Indicator.**

d) **Speedometer with Recording Odometer.**

e) **Fuel Quantity Gauge(s).**

f) **Equipment Controls.**

23. SHEET METAL COMPONENTS.

a. **General.** The carrier vehicle engine, as well as its mechanical components, shall be protected wherever possible from snow, rain and other winter elements. Body and engine enclosures shall be fabricated from aluminum, fiberglass, and steel. Self tapping bolts are unacceptable in the construction of these enclosures.

b. **Body Accessories.** The following parts and accessories are necessary for operational safety:

1) **Steps.** Four-way safety tread design steps are required to ascend and descend certain high profile carrier vehicles. These steps, together with assist handles, shall be of ample size to ensure safe and easy access for persons wearing bulky winter clothing.

2) **Walkway.** A four-way safety tread design walkway shall be provided, as necessary, for access.

3) **Handrails.** Handrails shall be provided as required at all steps, walkways, and work stations. They shall be made of corrosion-resistant materials or otherwise treated to prevent corrosion.

4) **Fenders.** All carrier vehicles shall be equipped with fenders and when determined by the operator, non-sail mudflaps to prevent wheels from throwing snow and other debris.

5) **Drains.** Plugged or free flowing drains shall be provided at all body and compartment locations where standing water can collect. Free flowing drains shall not drain onto sensitive mechanical or electrical components or on areas anticipated to be occupied by personnel during normal operations.

6) **Doors.** Doors shall be equipped with a positive closing mechanism and, where appropriate, a locking mechanism. Top hinged compartment doors shall be held in the open position by support arms.

7) **Gutters.** The vehicle cab shall be equipped with gutters, located above the entrance doors, of sufficient length to span the door width and provide runoff protection to occupants either entering or exiting the cab.

24. PAINTING, MARKING, AND LIGHTING OF VEHICLES.

a. **Painting and Marking.** The vehicle shall be painted Chrome-Yellow in accordance with color tolerance charts that have been made available for FAA regional airport inspectors and key potential users in the aviation safety equipment industry (see AC 150/5210-5B).

1) **Preparation and Finish.** The carrier vehicle and all mounted and towed equipment shall be cleaned first, then treated with a corrosion inhibitor, primed, puttied, sanded, and finally painted. The paint shall consist of not less than two coats of Chrome-Yellow polyurethane enamel having a combined minimum thickness of 7 mils.

2) **Quality.** The finished paint shall be free of "fisheye", "orange peel", chips, runs, or other imperfections that detract from the equipment's corrosion resistance and appearance.

25. MISCELLANEOUS.

a. **Name, Service, and Instruction Plates.** All information plates shall be made of either noncorrosive metal or plastic with the information engraved, stamped, or etched thereon. Plates shall be mounted in a conspicuous place with screws, bolts, rivets, or exterior type pressure sensitive tape.

1) **Plastic plates.** Plastic plates are acceptable only in locations that are not exposed to the elements and subject to weathering or excessive heat.

2) **Information.** Plates shall identify make, model, serial number, and any other relevant data.

b. **Technical Publications.** The manufacturer shall furnish two sets of the following publications:

1) **Operator's Manual.** The operator's manual includes lubrication charts and instructions.

2) **Parts Manual.** The parts manual identifies and lists all parts, components, and sub-assemblies used in the fabrication of the carrier vehicle.

3) **Maintenance and Service Manual.** A maintenance and service manual provides guidance to non-specialists performing routine services. The manual should also describe in detail with appropriate schematics the overhaul and major maintenance procedures required to maintain the vehicle.

c. **Accessories and Tools.** The carrier vehicle shall be equipped with the following tools and accessories. They shall be kept in a secure and readily accessible enclosure that is permanently affixed to the vehicle.

1) **Tire Tools.**

2) **Jack.** A jack specifically adapted to the carrier vehicle that is capable of raising it to a position where a flat tire can be changed.

3) **Shear Pins.** A minimum of six pins shall be provided in support of each shear pin located on the carrier vehicle and its auxiliary equipment.

4) **Specialized Tools.** Specialized tools required for routine servicing of the carrier vehicle and its auxiliary equipment.

26. DELIVERY.

a. **Preparation for Delivery.**

1) **Shipment.** The vendor "seller" is responsible for the safe and timely delivery of the vehicle and its accessories, spare parts, and tools to the agreed place of delivery.

2) **Marking.** Carrier vehicles shall be marked for shipment in accordance with instructions agreed to by the purchaser.

b. **Instruction and Training.** The manufacturer shall, at no additional cost, furnish the services of trained personnel to the purchaser at a time and place agreed to by all parties. These individuals shall provide instructions to airport personnel sufficient for the personnel to familiarize themselves with the operational and maintenance characteristics of the vehicle and its auxiliary equipment. The period of instruction shall not be less than 24 hours.

APPENDIX 2 - OPTIONAL/ALTERNATE EQUIPMENT SPECIFICATION

1. **GENERAL.** Most snow and ice control equipment is designed to operate under normal winter conditions. At various times, working tolerances and/or severe weather or operating conditions require specialized support equipment to assist the primary unit prior to or during operation. Several of these options are discussed below:

2. **CARRIER VEHICLE.**

Equipment to be considered when operating a carrier vehicle at or below -40°F (-40°C) or when the vehicle must be stored outside or in an unheated building is as follows:

a. **Engine/Transmission.**

1) **Engine-Jacket Water Heater.** Recirculating type with thermostatic control and weatherproof receptacle plug (minimum - 1500 watts).

2) **Engine Oil Pan Heater.** 300 watts

3) **Battery Warmer Pad.** Approximately 50 - 100 watts per battery

4) **Transmission Oil Pan Heater.** Wattage as recommended by the transmission manufacturer

b. **Vehicle Cab.**

1) **Additional Door Handles.** Handles shall be installed on lower part of vehicle cab door.

2) **Auxiliary Cab Heater and Circulating Fans.**

3) **Mirrors.**

a) **Remote Control for Exterior Mirrors.**

b) **Electrically Heated Exterior Mirrors.**

4) **Windows.**

a) **Grooved Windshield.**

b) **Extra Window in Lower Part of Cab Doors.**

c) **Sliding Rear Windows.**

d) **Tinted Windshield and Windows.**

e) **Reverse Slope Windshield.**

5) **Seats.**

a) **Bostrom "T" Seat.** (or equivalent for driver and passenger sides)

b) **Heated Driver Seat.**

c) **Arm Rests for Operator Seat.**

d) **Air Suspension Seat.**

6) **Cab Insulation Upgrade** (to reduce exterior noise below 85dBa)

7) **Air Horn.**

8) **Clock.**

9) **Additional Lighting.**

a) **Auxiliary Cab Dome Light.**

b) **Roof Mounted Lights.**

c) **Door Lights.**

d) **High Intensity Strobe Beacon.**

c. **Mechanical.**

1) **Special Starting Systems.**

a) **Dual Battery System.**

b) **Ether Cold Starting System.**

2) **Permanently Installed Battery Charger.**

a) **Maintenance Charging.** (0-10 amp capacity)

b) **Automatic cutoff.**

c) **Connection.**

i. Weather resistant and chassis mounted.

ii. Adaptable to 110 volt electrical outlet

iii. Heavy duty

iv. 20 amp capacity

3) **Engine Cooling.**

a) **Oversize Radiator.**

b) **Radiator Shutters.** (if compatible with engine design)

4) **Automatic Engine Shutdown.** An automatic engine shutdown system is equipped with an override switch to prevent engine damage due to low engine oil pressure, high coolant temperature, or low coolant level.

5) **Special Alternator.** Specify drive type, amperage, and voltage.

6) **All Wheel or Articulated Steering.** For all-wheel steering systems, the rear drive-steer axle shall be controlled in the cab.

7) **Silicone Hoses.**

d. **Extra Fuel Capacity.** Extra fuel capacity should be specified by quantity (gallons/liters) and not by tank size and location.

e. **Tire Chains.**

f. **Voltage Converter.**

g. **Additional Corrosion Prevention.** If additional corrosion preventatives are being considered, they should conform to Federal Specification 297 D, Rustproofing of Commercial (Nontactical) Vehicles.

h. **Quick Disconnect Hitches.**

1) **Automatic/Remote Hitch.** Controls to activate the hitching and unhitching mechanisms shall be located in the vehicle cab. The hitch shall be capable of mating the plow equipment to the carrier vehicle attachment points even when minor angular differences exist between the attachment points and the hitching assembly. An additional hydraulic, pneumatic, or mechanical locking/unlocking device may be installed to ensure safe and positive final coupling. Locking devices shall be activated through the use of existing vehicle power systems.

2) **Semi-Automatic Hitch.** The initial hook-up between carrier vehicle and hitching device shall be controlled from the vehicle cab with final lock-on accomplished manually at the vehicle/ hitch interface. The hitch shall be capable of initial hook-up even when minor angular differences exist between the plow attachment points and the hitching assembly. All manual locking devices shall ensure a safe and positive final coupling.

i. **Tow Chain.** Tow chains shall have a minimum link size of 1/2-inch (1.3 cm).

j. **Radio Transceivers.** Each transceiver shall be equipped with its own microphone, antenna, and remote speaker. VHF radios used to communicate with air traffic control facilities shall satisfy the criteria set forth in section 3 of Radio Technical Commission for Aeronautics document DO-186, "Minimum Performance Standards for Airborne Radio Communications Equipment Operating Within the Radio Frequency Range 117.975 - 137.000 MHz.," dated January 20, 1984. This document may be examined at any Federal Aviation Administration Regional Office or purchased from: RTCA Secretariat, One McPherson Square, 1425 K Street, NW., Suite 500, Washington, DC 20005. Transceivers using other frequencies shall meet applicable standards of the Federal Communications Commission.

3. **ROTARY PLOW.**

a. **Low Temperature Options.**

1) **Engine-jacket water heater.** (1,000 watt unit)

2) **Engine oil pan heater.** (300 watt unit)

3) **Battery warmer pad.** (500 watt unit)

b. **Spot Casting and Loading Chute.**

4. DISPLACEMENT PLOW.

a. **Moldboard Coatings.** Polyurethane nonstick coatings when applied to the front face of a moldboard will reduce skin friction and prevent snow from sticking onto the moldboard.

b. **Snow Deflector Shield.** A snow deflector shield may be attached to the upper edge of a displacement plow moldboard. Attaching devices are hinges, bolts, and acceptable spring-loaded mechanisms.

5. MATERIAL SPREADERS.

a. **Dry Material Spreaders.**

1) **Vehicle Speed Sensor System.** This system shall automatically regulate and match the material spread rate with vehicle speed. Operation of the system shall be from the vehicle transmission or directly by auxiliary tire traction. The system shall include an automatic material cut-off.

2) **Belt Over Chain.** Attached to the standard conveyor chain, the belt provides a more positive delivery of product to spinner resulting in a more uniform spreading pattern.

3) **Load Choker.** An inverted "V" type adjustable load choker will reduce the load pressure on the conveyor system of larger spreaders.

4) **Cab Shield.** Shield projects from top of leading edge of the spreader over the truck cab. Its function is to protect against spillage of material on cab and drive train of carrier vehicle during loading.

5) **Additional Box Height.**

6) **Chain Oiler.** Oiler operates by gravity flow and keeps conveyor chain oiled during operation.

7) **Hopper Cover.** Cover runs the full length of the hopper and protects the load from the elements.

8) **Catwalks.**

9) **Mud Flaps.**

10) **Additional lighting.**

b. **Liquid Material Spreaders.**

1) **Calibration System.** The calibration system shall consist of a control console, a sensor control valve, a ground speed sensor, and an application rate sensor. It shall maintain a uniform application rate at all normal carrier vehicle application speeds with the entire width of boom or any combination of sections thereof.

2) **Flusher Unit.** A flusher unit shall have four broad fan nozzles capable of delivering 150 gpm at 50 psi.

3) **Quick Disconnect Hitch.** A quick disconnect hitch for a displacement plow should be considered when purchasing a self-contained spreader unit.

APPENDIX 3 - ROTARY PLOW SPECIFICATIONS

PART A - AIRPORT OPERATOR CHECKLIST

FORWARD: When preparing a solicitation to purchase a rotary plow, an airport operator or specification writer should use PART A to identify user requirements and PART B to define the specification to meet these requirements. Part A is important because it tailors the rotary plow to the unique requirements of the purchaser, i.e. single stage versus two stage, solid auger versus turbine impeller etc. Both parts, when combined, become the technical basis for the users request for proposal.

1. Anticipated uses and/or features of rotary plow. (Be Specific).....

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2. Capacity ..... tons/hr.

3. Casting Distance..... ft(m) @ Snow wgt.of.....lb/ft^3(kg/m^3)

4. Anticipated Speed of Operation ..... mph (km/h)

5. Unique Problems. (if any)

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.....

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6. Optional Equipment.

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PART B - ROTARY PLOW SPECIFICATIONS

1. **TWO-STAGE ROTARY.** This unit shall have distinct input and discharge stages. The input first stage disaggregator (snow gathering device) cuts and then forces the snow into the second stage discharge impeller.

a. **Rotary-Head Box.** Fabrication shall be of heavy gauge welded alloy steel designed for the type of expected service. The rotary-head box shall have provisions for vehicle mounts, shoe or caster brackets, scraper blades, drive lines, controls, augers, and impeller bearing mounts, and other mechanical hardware. A scraper blade shall be fitted to the lower leading edge of the box which shall be removable and made of high carbon steel or polyurethane. The blade shall run the entire width of the box.

b. **Input Auger (Ribbon Reel).** Generally, the ribbon reel auger should have a minimum of two bearing supports, one at each end of the auger shaft (some designs may be configured differently). The ribbon blades shall be made of high tensile steel bolted or welded to the auger shaft and balanced to reduce vibration.

c. **Input Auger (Solid).** The solid auger shall have multiple cutter blades mounted on the auger drive shaft. Discharge impeller blades shall also be mounted on the shaft. The solid auger drive shaft shall be balanced and supported by bearings on the discharge end.

d. **Discharge Impeller System.** The impeller capacity shall be at least equal to the capacity of the input augers. The impeller blades shall be made of high tensile steel and be balanced to reduce vibration and shock damage.

e. **Operation of the Rotary System.** Operation of all disaggregator, auger, and impeller systems shall be by either hydrostatic or mechanical means with the speed controlled by a single operator in the vehicle cab. Power shall be transmitted to these systems via mechanisms located on either side of or in the middle of the rotary head box. To ensure efficient snow flow where an auger and impeller share the same drive shaft, there shall be a reduction gear system between the two to provide a proper meshing of impeller speed and auger speed.

2. **SINGLE-STAGE ROTARY.** This unit shall use the same rotary assemblies for input and discharge. The assembly shall be of either single or dual turbine design. The unit need not have a pre-cutter bar to break up ice and encrusted snow.

a. **Turbine Box.** Fabrication shall be of heavy gauge welded alloy steel designed for the type of expected service.

b. **Turbines.** Turbines shall be supported by bearings of adequate size for maximum expected snow loads and turbine velocities. The turbines shall be made of high tensile steel. Additional vertical side augers may be installed to improve efficiency.

c. **Turbine Drive.** The operation of turbines shall be by either hydrostatic or mechanical means with the turbine rotation speed controlled by a single operator inside the vehicle cab. The drive shall be engaged to the power train behind the turbine box and shall be fully accessible for maintenance purposes.

3. **STANDARD SINGLE AND TWO-STAGE ROTARY EQUIPMENT.**

a. **Snow Casting Assembly.** The casting assembly shall consist of a casting chute(s) that can be directionally controlled, a snow collector of either impeller or turbine design, and a control system. The casting chute(s) shall be able to rotate in either a vertical or horizontal plane and be able to flat cast either to the left or right. Casting distances shall range from zero to the maximum cast distance specified by the manufacturer for the class of rotary plow under consideration. The snow casting chute(s) shall be designed and positioned on the carrier vehicle so as to provide maximum operator visibility. Chutes shall be controllable by a single operator from within the vehicle cab.

b. **Rotary Head Assembly.** The rotary head assembly shall be equipped with either a hydraulic or mechanical lifting device that is capable of raising it a minimum of 8 inches (20 cm) from the pavement surface. The device shall be activated through the use of conveniently located controls in the vehicle cab. The drive system shall not bind, rub, or vibrate excessively when the assembly is being moved. When the vehicle is traveling, the assembly shall be supportable in the raised position.

c. **Drive Protection System.** All auger and impeller assemblies shall be protected against sudden stops or damage that may be caused from foreign objects. Protection may be in the form of automatic clutches, release overrides, and/or shear fasteners.

d. **Blower Head Drive Train.** Drive shafts, universal joints, and other mechanical components of the drive train shall continue to provide power to the head assembly under normal operating conditions even at angles of up to 15 degrees from their driveline rotation planes.

APPENDIX 4 - DISPLACEMENT PLOW SPECIFICATION

PART A - AIRPORT OPERATOR CHECKLIST

FORWARD: When preparing a solicitation to purchase a displacement plow, an airport operator or specification writer should use PART A to identify user requirements, and PART B to define the specification to meet these requirements. Part A is important because it tailors the displacement plow to the unique needs of the purchaser, i.e. type of plow desired, type of moldboard, plow shoes versus caster wheels etc. Both parts, when combined, become the technical basis for a users request for proposal.

1. Anticipated uses and/or features of displacement plow. (Be Specific).....

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2. Type of Plow Preferred .....

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3. Plow length.....ft(m), height.....ft(m), width.....ft(m)

4. Unique Conditions/Obstructions that may be Encountered.....

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5. Typical Snow Conditions.....

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6. Moldboard.....steel.....non-steel

7. Other.....

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PART B - DISPLACEMENT PLOW SPECIFICATION

1. **FRONT-MOUNTED PLOWS.**

a. **One Way Fixed Angle Plow.**

1) **Geometry.** The front-mounted moldboard shall be made of either smooth rolled or brake formed steel or be a steel frame-polyethylene surfaced combination having similar strength characteristics. Its cross sectional profile shall be curved and tapered with a minimum height of 25 inches (64 cm) at the intake end and up to 72 inches (183 cm) at the discharge end. The length of the cutting edge should be no less than 10 feet (3 m). The intake end shall have a side plate to control and prevent snow spillage.

2) **Features.** The push frame shall feature adjustable angles of attack or cutting edge angles with a maximum fixed plow angle of 37° for best snow removal efficiency. The moldboard pitch adjusting bar shall have a shear pin to prevent damage to plow as well as carrier vehicle and the unit shall be equipped with a rear swivel bar to permit the plow to follow surface contours more closely. Skid shoes or caster wheels should be installed to support the plow and prevent its cutting edge and/or moldboard frame from digging into the pavement.

b. **Power Reversible Plow.**

1) **Geometry.** The front-mounted moldboard shall be made of either smooth rolled or brake formed steel or be a steel frame-polyethylene surface having similar strength characteristics. Its cross sectional profile is curved with a minimal height and cutting edge length of 35 inches (89 cm) and 10 feet (3 m) respectively.

2) **Features.** The reversing assembly shall be hydraulically activated and be capable of operating in both raised and lowered positions. The assembly shall provide a minimum of five moldboard positions, two each for the left and right side of the bulldozing position. The maximum left/right plow angle shall be no less than 37°. Large snowplows with moldboards longer than 15 feet (5 m), shall have a maximum cutting edge angle of no less than 65°measured from the verticle. The unit can be equipped with an automatic moldboard locking and unlocking feature, i.e. lock latch for different angles to relieve pressure from hydraulic cylinders.

c. **Rollover Power Reversible Plow.**

1) **Geometry.** The front-mounted moldboard shall be made of either smooth rolled or brake formed steel or a steel frame-polyethylene surfaced combination having similar strength characteristics. It shall be curved and deeply tapered with a minimum height of 18 inches (46 cm) at the intake end and up to 72 inches (183 cm) at the discharge end. The length of the cutting edge should be a minimum of 10 feet (3 m).

2) **Features.** The maximum left/right plow angle shall be no less than 37°. The moldboard rotation mechanism shall be accessible for both servicing and lubrication and be fully enclosed and sealed with durable safety shields. The system shall have a locking feature for transportation and storage. The front-mounted moldboard shall be capable of plowing, either to the right or left at the same fixed angle, by rotating the moldboard assembly 180°. The rotating mechanism shall be capable of rotating the plow from right to left hand discharge in 15 seconds or less while the carrier vehicle is in motion.

d. **Power Reversible Plow with Folding Wings.**

1) **Geometry.** The front-mounted moldboard assemblies shall consist of a main center section having a constant minimum height of 35 inches (89 cm) and two folding wing sections located on either side of the center section. It shall be made of either smooth rolled or brake formed steel, or a steel frame-polyethylene surface combination having similar strength characteristics. The height of the folding wings shall gradually increase from the center section height towards the discharge end for improved snow lift. The length of the total system shall not exceed 30 feet (9 m) with the center plow cutting edge no less then 9 feet (2.8 m) and individual side wings no less then 5 feet (1.5 m).

2) **Features.** Heavy-duty casters shall support the center section and the two hydraulically actuated wings. Hinges supporting moldboard wings shall be at the third points. The design of the reversing mechanism and the wing sections shall minimize pressures on the cylinders.

e. **Flexible Reversible Plow.**

1) **Geometry.** The moldboard shall be made of continuous flexible polymer construction supported by a frame consisting of perimeter bracing and hydraulically driven reversing mechanisms. The moldboard shall be capable of changing its crossectional shape, curling down to a height of 33 inches (84 cm) along its full length or opening to at least 50 inches (127 cm) at the discharge end. The cutting edge shall be at least 9 feet (2.7 m) long and be equipped with a tripping edge devise.

2) **Features.** This type of moldboard has the ability to change its geometric shape to achieve a higher casting funnel configuration in both left and right plowing directions. It is durable, light-weight, corrosion resistant, and possesses a low coefficient of friction that can result in fuel savings. Because it is flexible, it can meet a variety of weather and snow conditions. In its curled down position the casting distance is reduced, but so is the problem of snow-blowback.

f. **Ramp Dozer.**

1) **Geometry.** The front-mounted moldboard design shall be a deeply recessed curve having a minimum height of 56 inches (142 cm) with optional full side plates to control and minimize snow spillage.

2) **Features.** This unit may be mounted on an aircraft tug, wheel loader, industrial 4x4 tractor, or vehicles of similar design. The design of the moldboard hitch shall be based on a quick disconnect configuration. Depending upon intended use, plows shall have a minimum of either two shoes or two casters. Casters or shoes are not necessary when the moldboard is connected to a wheel loader. Parking legs shall be provided if plow shoes/casters do not provide adequate support to prevent the moldboard from overturning when it is being disconnected from the carrier vehicle. If the plow assembly offers adjustable angles, the maximum cutting edge angle shall be no less than 65° measured from the verticle.

g. **Expressway Plow.**

1) **Geometry.** The moldboard length of an expressway plow may extend to a maximum of 15.0 feet (4.6 m) with a limiting nose height of 38 inches (97 cm) and a maximum discharge height of 70 inches (178 cm).

2) **Features.** The moldboard shall have a straight cutting edge that transitions to an upper edge which is flared to the left and right about its centerline. The plow should be adjustable manually and/or hydraulically to a maximum of 42° either side of the straight ahead bulldozing position. The plow may also feature several pitch positions (from the vertical) giving it more efficient plowing characteristics and the improved safety of a trip blade. Plows shall be equipped with either skid shoes or caster wheels to allow them to more closely follow pavement surfaces.

h. **Vee Plows.**

1) **Geometry.** The overall length of a vee plow normally does not exceed 13.0 feet (4 m). Nose heights vary depending on plow length and may range as low as 36 inches (91 cm) or reach a maximum of 60 inches (152 cm). The wing height at the point of discharge maximizes at about 105 inches (267 cm).

2) **Features.** These types of plows may be used alone or in combination with leveling wings. The low nose provides good operator visibility. Plows shall be raised or lowered hydraulically using controls within the carrier vehicle cab. The plow shall be equipped with a nose divider that shears snowdrifts and helps to stabilize the plowing course. Snow deflectors shall either be part of the plow or attached by a spring hinged device. Plows may be equipped for attachment to either carrier vehicles, graders, or wheel loaders.

i. **Snow Bucket and Snow Basket.**

1) **Snow Bucket.**

a) **Geometry.** The capacity of a front mounted bucket shall range anywhere from 3 to 8 yd^3 (2.4 to 6.2 m^3) depending upon the type of snow removal operation.

b) **Features.** The bucket shall be made of welded construction using high-strength, wear resistant steel plate, and bracing. It shall be equipped for mounting on a wheel loader or industrial 4x4 tractor. The installed bucket shall be capable of sustaining a level load while being tilted 20° in the forward and transverse position. It shall be equipped with a quick coupler hitch for swift changeovers. Snow buckets may have a built up bottom of abrasion resistant steel to improve wear life.

2) SNOW BASKET.

a) **Geometry.** The front-mounted basket width shall range from 8 to 17 feet (2.4 to 5.2 m). The basket hitching assembly shall be designed for easy mounting on a wheel loader or industrial 4x4 tractor.

b) **Features.** The basket shall have the same pick up and discharge characteristics as a snow bucket, e.g., capable of being tilted a minimum of 20° in a forward or transverse position with a level load. It shall have a quick coupler hitch for swift changeovers. Baskets shall be welded using flexible high strength wear resistent steel weaving over a steel frame. Construction shall be of minimum weight capable of withstanding the rigorous stress of loading and unloading. Snow baskets may have a built-up bottom of abrasion resistant steel to improve wear life.

2. SIDE-MOUNTED WINGS.

a. **Extension Wings.**

1) **Geometry.** The side-mounted moldboard may feature either a trip or non-trip design and be curved and tapered with shock absorbing side braces and mounting posts. Moldboards shall be made of hot rolled carbon steel having a minimum 8 U.S. SG gauge thickness or of non-steel materials having similar characteristics. They shall have an intake height of at least 26 inches (66 cm) and a discharge height of at least 34 inches (86 cm). The extension wing shall feature a cutting edge of either standard or trip edge design and have a minimum "effective" cutting angle length of 5 feet (1.6 m).

2) **Features.** Extension wing assemblies shall be able to position the plow hydraulically so that the cutting edge can be moved a vertical distance up to 36 inches (91 cm) from the pavement surface. The wing assembly shall feature energy absorbing mechanisms designed to relieve the impact of obstacles. The moldboard shall attach to posts mounted on the carrier vehicle frame. When the unit is not in use, the moldboard shall be capable of being folded hydraulically against the side of the carrier vehicle, maintaining a minimum clearance of 3 inches (8 cm) between the moldboard and vehicle. The design of the wing assembly will allow the moldboard to be easily detached from the front and rear posts.

b. **Leveling Wings.**

1) **Geometry.** The side-mounted moldboards shall be curved and tapered with a minimum intake height of 25 inches (64 cm) and a minimum discharge height of 35 inches (89 cm). They shall be made of hot rolled carbon steel having a minimum 8 U.S. SG gauge thickness or of non-steel materials having similar characteristics.

2) **Features.** The moldboard shall have the capability of being raised and lowered hydraulically. Push rods with shock absorbers and hydraulic wing adjustments, such as telescoping wing tubes/rods, shall regulate the lifting and lowering speeds of the moldboard. When not in use, the moldboard shall be capable of being folded hydraulically against the side of the carrier vehicle to maintain a minimum moldboard to vehicle clearance distance of 3 inches (8 cm).

3. UNDERBODY-MOUNTED SCRAPER.

a. **Geometry.** The underbody mounted scraper shall have a minimum length of 10 feet (3 m) with a minimum height of 12 inches (30 cm). The unit shall be made of high strength wear resistant steel with a moldboard thickness of no less than 1/2 inch (1.3 cm).

b. **Features.** The moldboard assembly shall be equipped with a shock absorbing system to prevent damage from suddenly applied loads. The moldboard shall fold or raise for transport with a minimum 6 inch (15 cm) road clearance. Construction of the underbody moldboard hanger shall provide the maximum load bearing distribution surface for the moldboard. Manual or automatic moldboard turntable circles shall be welded with at least four position indexing locks. The shock absorbing system and locking cylinder shall relieve the reversing rams of all pressures using two locking cylinders. The unit shall be power reversible. The system shall have an adjustable ground pressure device that is controlled within the cab.

4. STANDARD DISPLACEMENT PLOW COMPONENTS

a. **Plow Assembly.** The plow assembly shall consist of the plow moldboard, drive frame, and cutting edges.

1) **Plow Moldboards.**

a) **Materials.** The standard manufacturing material for moldboards is 10 U.S. SG minimum abrasion resistant steel that is crimped, adequately ribbed, and reinforced. Non-steel moldboards having similar characteristics may be used in place of steel moldboards.

b) **Steel Moldboards.** Steel moldboards consist of the following features: horizontal stringers, vertical ribs, paneling, bracing, backup plates, and horizontal and vertical ribs at each hookup point. Other suitable methods of reinforcement are satisfactory providing the manufacturer adheres to acceptable construction techniques and standard engineering practices. Lifting grab-link areas and drive frame attachment points should be made of heavy welded construction with maximum reinforcing and backup plates. The use of metal castings shall be kept to a minimum on all plow load points to facilitate ease of field repairs and to reduce parts inventories.

c) **Non Steel Moldboards.** Non-steel moldboards shall be properly reinforced to ensure that their strength is equivalent to that of the standard steel moldboard. Typical non-steel moldboard materials are as follows:

i) **Aluminum.** Moldboards made of aluminum are lightweight and noncorroding but may be subject to bending under impact loads.

ii) **Composites.** Composite moldboards can be made from either fiberglass or matrix materials. These materials must be securely fastened to moldboard assemblies to reduce the possibility of material rupture and wear.

iii) **Polymers.** Moldboards made of polymer materials are lightweight, noncorroding and provide very good frictional qualities.

2) **Moldboards/Cutting Edges.** The moldboard design shall accommodate both metal and non-metal cutting edges. These edges shall have an installation alignment guide to allow adjustments to within 1/16 inch (2 mm) of the desired setting. Moldboards shall be detachable from the drive frame. The moldboard vertical plane adjustment assembly shall be ruggedly designed, and be equipped with rubber recoil bumpers to absorb shocks.

3) **Drive Frame.** The drive frame shall be of either oscillating or floating design, readily detachable from the push frame of the carrier vehicle. A drive frame equipped with adjustable oscillating bars allows the plow to follow surface contours without putting excessive strain on the carrier vehicle chassis. Floating drive frames must be capable of supporting the weight of the displacement plow, and not have it transferred to the carrier vehicle's lift device. Where possible, drive frames shall be provided with a reversing mechanism that can easily be detached from the carrier vehicle's push frame. The use of metal castings should be kept to a minimum.

4) **Cutting Edges.** Cutting edges can be made of either tungsten carbide-tipped steel or a non-metal product such as plastic, polyurethane, or rubber. Non-metal edges shall be pre-cut and shall not fail due to extreme cold under normal working loads or when making contact with pavement obstructions. Cutting edges of either type shall be punched in accordance with AASHO standard hole spacing requirements.

b. **Safety Trip Devices.** When it is appropriate, an automatic safety trip device shall be installed on a displacement plow assembly to prevent damage to the moldboard, cutting edge, and vehicle and to ensure driver safety. Acceptable tripping systems include springs, torsion mechanisms, hydraulic cushion type devices, cutting edge tilt devices, and high-lift safety tripping devices. They shall be positioned and designed to be easily adjustable. Ramp dozers which operate at low speeds need not have a safety trip device.

c. **Lifting Device.** Lifting devices shall be attached and adequately braced to the push frame or the carrier vehicle's chassis frame. The lifting mechanism may be either hydraulic or pneumatic and capable of raising the displacement plow at least 12 inches (30 cm) from the ground surface.

d. **Automatic Plow Locking Devices.** Automatic plow locking devices shall be installed, where they are needed to relieve hydraulic or pneumatic pressures on lifting cylinders. No hydraulic, pneumatic, or mechanical loads shall be placed on reversing mechanisms. Acceptable positive plow locking designs may include worm and sector, hydrostatic, and ratchet/detent devices. The automatic positive engagement and release mechanisms shall be designed so that low temperatures, sand, chemicals, snow, slush, and ice do not adversely effect their operation.

e. **Push Frame.** The push frame shall be mounted on the front of the vehicle chassis frame with minimum overhang. Adequate reinforcement and bracing of steel side plates shall meet the design requirements of the carrier vehicle manufacturer.

f. **Extension and Leveling Wing Plow Posts and Side Braces.** All post members and side brace assemblies shall be made of steel construction. The minimum clearance between the plow and vehicle cab, while the moldboard is in the raised and folded position, shall be no less then 3 inches (8 cm).

1) **Front Posts.** The front posts are mounted to the push frame or attached to the sides of the chassis frame. They shall be adequately reinforced to accommodate loads that may be transmitted by side braces. Short front posts shall be capable of raising the plow moldboard, either hydraulically or pneumatically, at least 36 inches (91 cm) above the ground surface while long posts shall be capable of lifting it at least 60 inches (152 cm) above the ground surface. The posts shall incorporate shock absorbing safety devices and adjustable safety chains to secure the plow moldboard during transit.

2) **Rear Posts.** Rear posts are mounted to the sides of the chassis frame with adequate reinforcement for the attachment of side braces. The design and installation of the rear post mountings shall comply with the requirements of the vehicle manufacturer. Rear posts shall be fixed, hydraulic, or pneumatic depending on requirements to lift side-mounted plows. Rear posts shall incorporate shock absorbing safety devices. Adjustable safety chains shall be installed on rear posts to secure the moldboard in a safe folded position during transit.

3) **Side Braces.** The side braces are adjustable to allow manipulation of the extension plow moldboard. Side brace designs shall feature shock absorbing safety devices.

g. **Pilot Valve Controls.** Operation of the plow is accomplished through pilot valve controls of either electrical/hydraulic, air/hydraulic or cable/hydraulic design. Selector controls, located in the vehicle cab, shall be actuated easily under severe winter conditions.

h. **Plow Shoes and Caster Wheels.**

1) **Plow Shoes.** Replaceable shoe assemblies or shoe assemblies equipped with replaceable wear plates are acceptable support for the drive frame. Both types of shoe assemblies shall be highly resistant to shock and abrasion. The design shall provide easy and positive vertical adjustment. Typical plow shoe types are as follows:

a) **Fixed Shoes.** These non-adjustable shoes are mounted directly behind the moldboard cutting edge.

b) **Adjustable Shoes.** These shoes shall be easily adjustable and mounted on the drive frame.

c) **Mushroom Shoes.** These shoes shall be easily adjustable and mounted on the drive frame.

d) **Scuff Shoes.** Scuff shoes fitted on either side of moldboard provide added protection from side obstructions.

2) **Caster Wheels.** Caster wheels shall be required when non-metal cutting edges are standard. Typical examples of caster wheels are as follows:

a) **Metal Wheels.** Metal caster wheels must be capable of supporting the plow without shimmy under all operating conditions. The swivel dampeners on large plows (15 ft (4.6 m) and larger) and the caster wheel height positioning mechanisms shall be designed to allow quick and easy adjustment with positive stops to limit caster rotation. Metal caster wheels shall be designed to prevent damage to in-pavement lighting fixtures. The caster swivel, thrust, and wheel bearings shall be sealed and protected and of ball or roller design with provisions for lubrication.

b) **Non-Metal Wheels.** This type of caster wheel shall have an adequate load-rated capacity to support the plow assembly and to function without damaging aircraft operating surfaces and in-pavement lighting fixtures. It shall also be durable and shall not separate from the metal rim during normal use.

APPENDIX 5 - MATERIAL SPREADER SPECIFICATION

PART A - AIRPORT OPERATOR CHECKLIST

FORWARD: When preparing a solicitation to purchase a spreader system, an airport operator or specification writer should use PART A to identify user requirements and PART B to define the specification to meet these requirements. Part A is important because it tailors the spreader to the unique preferences of the purchaser, i.e. special lighting, hopper/tank sizes, desired carrier vehicle cab features, unique safety equipment etc. Both parts, when combined, become the technical basis for a users request for proposal.

A. Solid Material Spreader.

1. Anticipated uses and/or features of spreader. (Be Specific).....

.....

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2. Size of hopper.....cu.yd, ...cu.m

3. Material to be Spread.....

4. Critical Application Rate.....oz/sy,.....gr/sm

5. Time Needed to Complete Major Operation.....minutes

B. Liquid Spreader

1. Anticipated uses and/or features of spreader. (Be Specific).....

.....

.....

2. Size of Tank.....gal,.....liters

3. Critical Application Rate.....oz/1000sf,.....liters/1000sm

4. Time Needed to Complete Major Operation.....minutes

5. Proximity to Loading Farm .....minutes

6. Capacity of Loading Farm.....gallons(liters)

7. Other.....

.....

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PART B - MATERIAL SPREADER SPECIFICATIONS

1. SOLID MATERIAL SPREADER COMPONENTS.

a. **Standard Equipment.** A solid material spreader shall have the following standard equipment:

1) **Hydraulic System.** The hydraulic system shall meet the basic design requirements of the carrier vehicle system which is described in Section 19 of appendix 1. It shall have the necessary power and controls needed for the safe and satisfactory operation of the conveyor, metering devices, spinners, and any other hydraulically operated attachment that is included as part of the spreader design. (See figure 4-5).

2) **Hopper Body.** The hopper body shell shall be constructed of heavy gauge carbon or stainless sheet steel, galvanized steel, or epoxy reinforced fiberglass. The side of the hopper shall have the necessary slope to provide an efficient flow of material to the conveyor/auger device. The shell and body support members have flanged, buttressed, or beaded edges for increased strength and support. There shall be vertical supports on each side of the hopper. The number of vertical side supports will depend on the hopper bed length as follows:

Bed Length	Side Supports
8 to 10 feet (2.4 to 3 m)	3
11 to 13 feet (3.3 to 4 m)	4
14 to 16 feet (4.3 to 4.9 m)	5

These supports shall be made of the same material as the hopper shell and extend the full height of the shell. The hopper end plates shall be continuously welded to the sides.

3) **Conveyor System.** The solid material spreader shall have an internal conveyor system. The floor bed of this system shall be constructed of steel having at least the same thickness as the hopper shell. The floor plate has lateral bracing consisting of external ribs welded to the conveyor floor bottom in at least three locations. Flexible sealers are mandatory and shall consist of replaceable belting or metal that prevents the hopper material from flowing over the conveyor sides. Belt sealers shall have lower removable supports of steel that extend the entire length of the hopper. The following types of conveyor systems are acceptable for use on airport spreaders:

a) **Chain Conveyor.** The chain conveyor has drag links constructed of high strength alloy steel chain. Pins shall be made of heat treated hardened steel and be exposed to reduce corrosion and permit lubrication. Steel cross bars shall be welded to every other drag chain link. Drive sprockets will have at least six teeth and be bolted to steel body members. Chain tension can be maintained by two heavy duty idler bearing adjustments. The conveyor shall be equipped with a chain wiper located on the rear of the roll-over plate.

b) **Belt Conveyor.** The belt conveyor is made of flexible, noncorroding, nonstretch, wear and heat resistant material. The belt shall be of an endless design supported by rollers having sufficient pitch to prevent belt sag. The drive roller shall provide no-spin power transmission to the belt under cold and slippery conditions. Drive and adjustment rollers shall be slightly crowned to facilitate belt centering and belt adjustment. Pillow blocks on the roller shall maintain adjustment.

c) **Auger Conveyor.** The auger conveyor is constructed of steel and shall accommodate an auger capable of conveying material smoothly from the front of the hopper to the rear. The auger shall be capable of moving this material in a level, continuous manner free of obstruction.

4) **Transmission System.** The transmission system is operated hydraulically or mechanically by either direct drive or a pavement traction drive. The system shall be controlled from the operator's cab.

5) **Pre-Wetting System.** This system shall pre-wet abrasives or solid chemicals during spreading operations. It shall consist of a corrosion resistant holding tank(s) properly baffled to reduce surge, mechanical or hydraulic pumps, fluid metering devices, and appropriate nozzles, valves, indicators and monitoring devices, including controls for the system which would be mounted in the cab. The system shall automatically provide for changes in flow rate coupled to changes in carrier vehicle ground speed. Application of prewetting agent shall automatically start when the carrier vehicle starts and automatically stop when the vehicle stops. All fittings and hoses shall be made of non-corrosive materials.

6) **Vehicle speed Sensor System.** This system shall automatically coordinate the material spread rate with vehicle ground speed. Power comes directly from the vehicle hydraulic system or via traction from an auxiliary tire. The system shall include provisions for an automatic material shutoff mechanism.

7) **Material Discharge.** The discharge gate is fabricated from sheet steel that is securely braced and flanged. It is capable of maintaining any setting and its lower edge shall be equipped with seals.

8) **Spinner Assembly.** The spinner assembly shall consist of the following:

a) **Spreading discs.** These discs shall be fabricated of steel plate or polyurethane and have a minimum of three equally spaced and replaceable discharge vanes capable of meeting the specified spread width.

b) **Material chute.** The material chute shall be constructed of the same sheet steel as the hopper and shall be designed to permit an unrestricted flow of material.

9) **Hopper Grates.** The opening of the hopper top shall have sectional heavy duty grates to assist in screening and breaking up of chemicals and abrasives during loading process.

b. **Services.** All spreader drive components shall have a minimal number of lubrication points with easy access for maintenance. The spreader shall receive lubrication prior to delivery with lubricants designated for use in winter conditions normally experienced at the delivery location. The spreader shall be conspicuously tagged to identify the lubricants and their temperature ranges.

2. **LIQUID MATERIAL SPREADER COMPONENTS.**

a. **Standard Equipment.** A liquid material spreader shall have the following standard equipment:

1) **Hydraulic System.** The spreader hydraulic system shall meet the basic requirements of the carrier vehicle system described in Section 19 of appendix 1. The system shall also be capable of supplying the power to operate the de-icing pumps, to fold the booms, and to turn the spreader on and off.

2) **Tank.** The tank shall be constructed of grade 304 stainless steel or better. Optional construction, using polymer or fiberglass materials, is acceptable providing that the manufacturer certifies that the materials used are capable of meeting the same stress and fatigue requirements as their stainless steel counterparts. The shell, head, and baffles of steel tanks whose capacity is 2000 gallons (7870 l) or less shall be made of at least 12 gauge material. For tanks whose capacity is greater than 2000 gallons (7570 l), these components shall be made of 10 gauge material. Sills for all tanks should be no less than 8 gauge and they shall also be made of grade 304 stainless steel. Baffle spacing for any tank should not be more than 44 inches (112 cm). Tanks shall be equipped with a manhole opening to allow inspection of the tank interior.

3) **Pumping System.** The pumping system must have sufficient capacity for full boom width spraying at a maximum discharge rate of 3 gallons/1000 square feet while operating at a speed of 30 mph.

4) **Spray Boom and Nozzles.** The spray boom shall be constructed in sections with each section capable of independent use. Boom design shall permit it to break away when an object is struck. Spray nozzles shall be equipped with check valves and be located to provide uninterrupted surface coverage. Filters shall be installed on lines leading to the spray booms.

b. **Services.** All spreader drive components shall have a minimal number of lubrication points with easy access for maintenance. The spreader shall receive lubrication prior to delivery with lubricants designated for use in the winter conditions normally experienced at the delivery location. The spreader shall be conspicuously tagged to identify the lubricants and their temperature ranges.

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